THE CAUSES AND EFFECTS OF DOMESTIC JOINT VENTURE ACTIVITY

BY

JEROME LAWSON DUNCAN, JR.

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To my Wife Judi and Daughter Leslie

TABLE OF CONTENTS

Abstract of Dissertation Presented to the Graduate Council
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Jerome Lawson Duncan, Jr.

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The thesis studies the causes and effects of domestic (U.S.) joint venture activity, where a joint venture is a separate corporation formed by two or more corporations. The study of effects, however, is limited to effects on firms' research and development expenditures and rates of return. Analysis is performed at both the firm and industry level. Further, analysis is restricted to large firm joint venture behavior.

The cross-firm analysis of the causes of joint venture activity employs a probit model to examine the determinants of joint ventures. The probit model is used since joint venture observations at the firm level are dichotomous. The analysis indicates that the probability of a large firm engaging in a joint venture increases with the firm's

size, financial leverage, and illiquidity. More rapid capital growth also increased joint venture activity in the Chemicals industry.

The cross-industry analysis of the causes of joint venture activity employs a cross-pooled regression model covering 19 industries over the years 1965-1975. At the industry level, indexes of the level of each industry's joint venture activity can be formed from the dichotomous firm level observations. Two indexes are formed: one based on technologically oriented joint ventures and one based on nontechnologically oriented joint ventures. Regressions are run with both of these indexes as dependent variables. The results of this analysis indicate that technologically oriented joint venture activity increases with an industry's research and development intensity, larger average firm size, more rapid capital growth, and lower profitability. Nontechnologically oriented joint venture activity increases with the same factors as technologically oriented joint ventures except for research and development intensity.

The cross-firm analysis of the effect on a firm's research and development expenditures indicates substitution: a firm which engages in a joint venture tends to reduce the amount it spends on research and development. Furthermore, long run involvement in joint ventures tends to cause an even larger reduction in research and development spending than does short run involvement.

The cross-firm analysis of the effect on a firm's rate of return indicates that rate of return is negatively related to joint ventures. The negative effect, however, becomes insignificant when measures of long run joint venture involvement are used, suggesting

that long run effects on rate of return are negligible. These cross-firm results suggest the broader interpretation that joint ventures are employed to acquire external knowledge with only short run adverse effects on rates of return.

The cross-industry analysis of effects employs the level and intensity indexes of technological, nontechnological orientation. In addition, indexes based on horizontality, nonhorizontality between the firms which formed joint ventures and indexes based on horizontality, nonhorizontality between the joint venture and the firm which formed it are employed. The results for the effects on industry average research and development expenditures indicate complementarity for broad groups of joint ventures, particularly those with a technological orientation or with a nonhorizontal relationship between firms. These results suggest that firms which do not engage in joint ventures increase their research and development spending in response to industry-wide joint venture activity.

The cross-industry analysis of effects on rates of return is performed using only the two sets of horizontality indexes. The results from that analysis lend support to hypotheses that joint ventures are used for market entry and knowledge acquisition, in that they reduce risk, reduce time lags, or serve other functional purposes. Further, part of the purpose of these rate of return tests was to search for possible evidence of anticompetitive behavior; however, any such evidence is weak and exists for only small segments of joint venture activity.

CHAPTER 1

THE CAUSES AND EFFECTS OF DOMESTIC JOINT VENTURE ACTIVITY

1.1 Joint Venture Definition and Relevance

A joint venture (JV) is a corporation or partnership formed by two or more separate entities. These entities are usually corporations, though combinations between corporations and individuals sometimes occur. Other forms of corporate interaction, such as mergers, are more prevalent, but joint ventures (JVs) do constitute a significant portion of corporate activity. For example, there were about 650 JVs, involving 952 firms, between 1964 and 1975. These JVs covered virtually every industrial sector in the U.S.

The goals and reasons for JVs are often very specific. Berg and Friedman [9] note that many JVs are formed to produce a specific product or offer a specific service. Consistent with specific goals are specific needs. Interindustry differences due to capital intensity, technology base, raw materials inputs, etc. can be expected to generate circumstances which create specific needs. In addition, individual firm circumstances, such as external funds requirements or market share, can generate specific needs.

The possibility that specific needs of a firm, whether they derive from industry or firm circumstances, give rise to JV formations is the starting point for this study. Using this proposition

as a starting point, the causes and effects of JV activity are examined in subsequent analysis. This analysis will yield further insight into those variables which affect, and are affected by, JV behavior.

1.2 Prior Studies Conflict

A need for further economic analysis into JV behavior is indicated from conflicting conclusions in prior studies. These conclusions have generally taken one of two sides: (1) some authors (e.g., Pfeffer and Nowack [46] and Mead [41]) emphasize the anti-competitive consequences from JVs; (2) others (e.g., Hlavacek, Dovey, and Biondo [27] and Berg and Friedman [9]) emphasize that JVs can yield gains unattainable through independent firm action. These gains may accrue, for example, from scale economies or from improved resource utilization when technology inputs are shared.

A profit motive can be seen as a common element in both sets of conclusions. The differences lie in the means of obtaining profits and the implications for regulatory control.

1.3 General Methodological Approach

A possible explanation for the conflicting conclusions is diversity in JV behavior. Some past studies have concentrated on particular industries, neglecting possible interindustry differences. Other studies have covered several industries but have not taken into account differences in the purposes of JVs. Differences in purpose may account for differing conclusions.

To illustrate the diversity in JV behavior, Table 1.1 presents a sample of JV occurrences for the period 1964-1973. For each industry, JVs are classified by their purpose. These purpose classifications are derived from Federal Trade Commission capture sheets. The capture sheets, in most cases, gave a statement of the firm's intentions. From this statement the broader classifications in Table 1.1 were constructed.

The table indicates interindustry diversity in the number of JVs. It also indicates diversity in purpose, since a number of purposes exists in any industry.

This interindustry and purpose diversity is an integral part of subsequent analysis. The specific needs of firms, which likely result in such diversity, and the conflicting conclusions of prior studies suggest that analysis should be disaggregated.

The basic approach will be to estimate relationships, through appropriate statistical procedures, at the most disaggregated level possible. Statistical procedures can then be applied to test for common influences, both across industries and across purposes. Through this approach some of the conflicting conclusions about JVs' causes and effects can be resolved.

1.4 A Common Theme

Though the general approach is disaggregated analysis, a common theme pervades. It is hypothesized that JVs are primarily used to

Table 1.1

Joint Venture Description by Purpose, 1964-1973

Industry Description	SIC[a]	Research & Development, & Exploration	Production, Marketing & Service	Construction
Metal Mining	10	15 (12)[b]	12	14
Oil and Gas Extraction	13	10 (8)	4	5
Nonmetal Mining	14	0	2	1
Construction	16	1 (1)	1	2
Food & Kindred Products	20	2	25	6
Tobacco	21	0	3	3
Textile Mills	22	2	10	1
Apparel Products	23	0	5	0
Lumber & Wood Products	24	0	1	9
Furniture & Fixtures	25	0	0	0
Paper Products	26	3 (2)	7	4
Printing, Publishing	27	2	11	2
Chemicals	28	24 (6)	57	14
Petroleum Refining	29	28 (18)	47	33
Rubber & Plastics	30	3	6	2
Leather Products	31	1	1	0
Stone, Clay, Glass	32	5	16	8
Primary Metals	33	7 (3)	28	20
Fabricated Metal Products	34	5 (2)	7	8
Nonelectrical Machinery	35	14 (1)	41	1
Electrical Machinery	36	12	33	2
Transportation Equipment	37	21 (1)	34	6
Instruments	38	6	13	0
Misc. Manufacturing	39	0	7	3

a Standard Industrial Classification

b The terms in parentheses are the number of Exploration JVs out of the total of Research & Development and Exploration JVs.

Note: Based on Compustat firms only, selected industries.

facilitate knowledge acquisition. It is generally recognized that knowledge is unevenly distributed among firms. Given uneven knowledge distribution, it is possible for two or more firms to jointly engage in an activity and to receive greater returns, or face less risk, than if the activity was independently pursued.

Knowledge acquisition, which would include any type of managerial expertise or proprietary information that can be shared, is not directly tested in its broad sense. Subsequent analysis focuses on a particular type of knowledge acquisition: that associated with new products or ideas and classified as research and development (R&D). Knowledge acquisition via JV, if it occurs, has important implications for the substitution of externally acquired knowledge versus internally developed knowledge.

Though the substitution of JV for R&D is the only form of substitution directly tested, some indirect tests of knowledge substitution in its broader sense are also performed. These tests involve JVs' impact on profitability.

Substitution is indicated if JVs have a negative impact on profitability. Some reasons why a negative impact on profitability would indicate substitution include the following. If JVs reduce risks associated with internal development, then profitability should be less. Knowledge purchased externally will command a lesser portion of economic rents than that developed internally since knowledge sellers will demand remuneration for their efforts.

1.5 Scope of the Study

The scope of the study is limited to domestic JVs in two industrial classifications: manufacturing and mining. A domestic JV is defined as one which is located in the U.S. and at least one parent[1] is a U.S. firm. There may be foreign firm involvement through parent participation, but the principal operation of the JV must occur in the U.S.

International JVs are omitted since special circumstances, not relevant to domestic JVs, can govern their formation. For example, host country requirements may preclude other forms of entry. Nonmanufacturing JVs are omitted since the specific needs of nonmanufacturing firms that led to a JV formation can differ significantly from those in manufacturing and mining. For example, technology sharing arrangements may exert a lesser influence on the decision to form a JV in nonmanufacturing industries, whereas substantial influence on the decision to form a JV may occur from technology sharing in manufacturing and mining.

1.6 Preview

Chapter 2 begins the analysis by providing a background review of previous work. First, a theoretical model of a firm's timing

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[1] According to a convention in the JV literature, the entities forming a JV are sometimes referred to as the "parents," and the JV itself is referred to as the "child."

decision for project selection is presented. This model is later expanded to illustrate some issues in the decision to JV. Next, issues raised in previous research into JV behavior are presented. Finally, since R&D models are important in subsequent analysis, a brief review of some issues in this area are presented.

Chapter 3 discusses the data. Further evidence of diversity is presented, as well as the methods employed to measure JV activity.

Chapters 4 through 8 present the more formal analysis. Chapter 4 begins by considering some factors which may influence the decision to form a JV, such as the effects from a firm's opportunity set and resources and effects from uncertainty. Next, the model of a firm's timing decision for project selection is expanded to include JVs. These theoretical considerations provide a background for the next chapter's analysis of the characteristics of parent firms.

The theoretical developments of Chapter 4 are then applied in Chapter 5 to estimate models of the causes of JV activity. Models at both the firm and industry levels are employed.

In Chapters 6 through 8 the analysis turns from the causes to the effects of JV activity. These effects are first examined across firms for a limited set of industries in Chapter 6. The first part of the chapter considers the impact from JVs on firms' R&D expenditures. The latter part of the chapter considers the impact from JVs on firms' profitability. These results will be interpreted in terms of firms' knowledge acquisition activities.

Chapters 7 and 8 concentrate on profitability and R&D expenditures, as related to JV activity across various industries.

Since JVs may have different impacts from different purposes, these chapters examine the impacts from JVs for various types of JVs. JVs are grouped by three dichotomous relations that are expected, a priori, to exhibit different effects on profitability and R&D. The three dichotomous relations are: (1) the purpose of the JV, broadly classified into technological versus nontechnolocial; (2) whether the parents were horizontally related versus not horizontally related; and (3) whether the parent and child are horizontally related versus not horizontally related. Horizontal relations are employed since anticompetitive effects are potentially stronger when a combination occurs between firms already operating in the same market.

Chapter 9 provides the summary and conclusions of the study.

CHAPTER 2

PREVIOUS THEORY AND RESEARCH

This chapter provides a background for analysis in subsequent chapters. First, a basic theoretical construct, as proposed by Scherer [54], is discussed. Next, a brief review of some issues raised in previous JV research is presented. Finally, since later chapters include analysis of the relation between JV and R&D, a brief review of some R&D issues is presented.

2.1 A Theoretical Model of a Firm's Timing Decision

Scherer's model examines the effect that market structure has on a firm's perception of optimal development time of an innovation. Figure 2.1 reproduces Scherer's diagram.

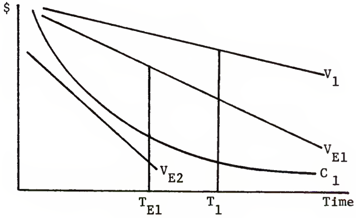

Figure 2.1

Benefits, Costs, and Timing of Innovation

Figure 2.1 represents a comparative statics view of a firm's position at one point in time. V_1 is the benefit function: the present value of revenues minus costs, other than R&D costs, at each time of product introducton. According to Scherer the benefit function is negatively sloped for two reasons: first, earlier introduction allows more periods of "monopoly" in the product for the innovator; second, earlier introduction has potential for permanent enhancement of the innovator's market share, called "first mover advantage."

The R&D cost function, C_1, is a nonlinear decreasing function of time because (1) total costs increase when time compression of development occurs due to increased errors that could be avoided if the process were more sequential; (2) information from one step may save money in another step if the second step is not begun until the information is obtained; (3) diminishing returns to additional scientists and engineers are experienced, given the state of scientific and technical knowledge at the time; (4) parallel approaches may be required to hedge against uncertainty associated with particular approaches to solving technical problems. The optimal time of introduction in this model is T_1 where the slope of the benefit function equals the slope of the cost function (i.e., where marginal cost equals marginal revenue).

The introduction of rivalry into the model will cause the benefit function to shift downward and take on a steeper slope. The model as formulated by Scherer allows for rival imitation which

diminishes the potential benefits. Two possible effects can occur as shown by the diagram. An increase in the number of equal sized rivals can shift the benefit function downward but still leave it above the cost function, curve V_{E1}. In this case rivalry creates a stimulus and increases the firm's R&D effort such that introduction time is compressed to T_{E1}. This occurs because the innovator enjoys temporarily what would otherwise be the market domain of its rivals.

The other possible effect is that the benefit function shifts to V_{E2} below the cost function. In this case the firm will abandon the project. Scherer supposes that this will happen in the situation where one firm is dominating the market. He predicts that the dominant firm will be an imitator when its market share is threatened and will accelerate its development efforts so strongly that the small challenger will relax its development pace. Thus, tight oligopoly is less conducive to research intensity.

The above framework can be applied to the decision to JV. In Chapter 4, its implications for relative bargaining positions of the parents, given rivalry, are analyzed. In particular, differences in risk aversion and opportunity sets lead to situations in which JVs can be mutually advantageous.

2.2 Review of JV Literature

Other researchers have examined aspects of JV activity. This review, however, focuses only on a limited amount of previous research since much of JV research falls outside the scope of this

study. For example, research covering international opportunity via JV, JV accounting, tax breaks in Puerto Rico, and so on are not relevant to the current domestic context.

Of past studies relevant to the current context, four broad areas will be covered. These are: (1) size of parent firm, (2) financial variables as determinants of JVs, (3) market power augmentation via JV, and (4) factor input complementarities or risk reduction as the motivation to enter a JV.

Size of parent firm has been found to be an important determinant in several studies. Boyle [11] concludes that JV participation increases as the size of the parent firm increases. Berg and Friedman [9] found that the technological aspects of JV behavior are affected by the size of the parent firm. In Hlavacek, Dovey, and Biondo [27] and Pfeffer and Nowack [46] the relative sizes of parents were found to be an important determinant of JV behavior.

While financial variables have received substantial attention in merger literature, relatively little attention has been given to the financial determinants of JVs. Boyle briefly notes that JVs provide complementary sources of capital and that financial risks can be shared. Berg and Friedman [7] note that certain tax advantages may accrue. Hlavacek, Dovey, and Biondo consider financial variables as determinants of JVs, but dismiss their importance.

Only Edström [15] focuses on the role of financial variables as determinants of JVs. He concludes that financial strength appears to be a determinant of JV behavior. His conclusion, however, has two

possible shortcomings in relation to current analysis. First, his study covers only Swedish firms. Swedish results may not apply to U.S. JVs. Second, he analyzes only industry characteristics. Conclusions drawn from analysis of industry characteristics need not apply to firm-level behavior.

Market power augmentation via JV, on the other hand, has received substantial attention in the literature. Several studies conclude that JVs facilitate market power. These studies generally base their conclusions on linkages between the parent firms or on the relation between JV activity and industry concentration. For example, Fusfeld [20] argues that large Iron and Steel firms use JVs to create market power through complex supply channel linkages. Mead [41] and Pfeffer and Nowack [46] conclude that market power augmentation derives from horizontal linkages between parent firms. Pfeffer and Nowack also argue that the high correlation between JV activity and industry concentration indicates market power augmentation. All of the above studies suggest tighter regulatory control based on the assumption that increases in market power indicate collusion.

A broad base of other studies concerned with market power augmentation via JV exist. Most, however, tend to be based on particular cases, as the Penn-Olin decision discussed in Meehan [42], or to stress general problems in applying antitrust law to specific instances, as Turner's [59] review of the application of Section 7 of the Clayton Act.

The final area, factor input complementarities or reduced risk as the motivation to JV, has also received considerable attention. Berg and Friedman [9] focus on the knowledge acquisition characteristics of JVs. Their analysis leads to the conclusion that motivations based on complementarities or risk reduction are probably more important than the creation of market power through collusion. The conclusions in Hlavacek, Dovey, and Biondo [27] strongly indicate factor input complementarities as the motivation to JV. They argue that JVs transpire as a result of small firms supplying technology while large firms supply marketing expertise.

Although his conclusions advocate regulatory retraint of JVs, Mead [41] cites justifications for JVs that are consistent with factor input complementarities or reduced risk. He cites high absolute capital requirements, inordinate risk, inefficiency from separate operations, and external economies. Any of these situations can lead to a dominance of shared inputs through JV over going it alone.

2.3 Review of R&D Literature

Since several places in subsequent chapters focus on the impact of JVs on firms' R&D expenditures, a brief review of some issues from the R&D literature is presented. For those interested, a more complete review appears in Kamien and Schwartz [31]. The present review simply highlights the issues about R&D expenditures that are important for later analysis. In particular, three issues are

reviewed: (1) productivity of R&D, (2) the determinants of R&D expenditures, and (3) R&D measurement and problems in measurement.

Productivity of R&D. A fairly strong consensus emerges from the literature concerning the characteristics of firms which produce major inventions: most major inventions derive from small to medium size firms. Typical are the studies by Jewkes et al. [29] and Mansfield [38]. The arguments advanced for this phenomenon are that innovation in initial stages is relatively inexpensive and that small firms attract better personnel, since inventors tend to be highly individualistic - a quality that may be lost or buried in a large firm.

Though small firms appear to have a comparative advantage in early stages of the R&D process, large firms appear to have comparative advantage as a product nears introduction time. Mansfield and Rapoport [39], for example, report that scale economies in application do exist since R&D projects at introduction time can require substantial outlays. Further, innovation yield greater total cost savings, or revenue increases, for larger firms.

The determinants of R&D expenditures. Past research indicates that a firm's size and a firm's profitability are two of the most important determinants of R&D expenditures.

Total sales is generally taken as the best proxy for firm size. Scherer [51] points out that total sales is more neutral to factor proportions than total assets. Further, total sales is less subject to accounting bias than total assets.

Beyond choice of the proxy, the question of functional form remains. Some past studies, for example Comanor [13], Hamberg [26], and Worley [61], adopt a log linear specification to elicit the effect of size on R&D. Scherer [51], on the other hand, proposes a cubic in sales. He recommends the cubic form since the log linear specification does not capture inflection points in the relation between R&D and size. Furthermore, evidence from Scherer [51], Mansfield [38], and others indicates interindustry differences in the R&D, size relation. Since the cubic function allows more flexibility for capturing industry differences, it seems preferable.

Profitability as a determinant of R&D expenditures has been shown in numerous studies. Examples are Mueller [45], Grabowski [22], Howe and McFetridge [28], and Branch [12]. The evidence indicates that a firm's R&D expenditures increase with profitability. Both rate of return and cash flow have been used successfully as proxies. In general, cash flow seems preferable since it bears a closer relation to spendable funds. However, a definite preference is difficult to establish.

R&D measurement and problems in measurement. A common source of R&D data, as well as for this study, is Compustat, and therefore the Compustat [57, Section 9, p. 57] definition of R&D is most appropriate. It is:

> Research and Development Expense includes all costs incurred, such as salaries, departmental expenses, etc. which are charged to operations as research expense. This amount is only the company's contribution. Any contribution by govern-

ment, etc. to the company's research and development program are excluded (unless it is impossible to determine the amount).

Part of the R&D measurement problem stems from R&D being recorded as an expense item, as suggested by General Accepted Accounting Principles. For economic analysis it would be preferable to capitalize R&D since R&D's benefits conceptually extend beyond when the expense is incurred. This difference, however, would cause no difficulty if year to year expenses were constant, an assumption one is forced to make if Compustat data are employed without adjustments. For a broad sample of Compustat firms adjustments to capitalized values are impractical to impossible, thus making this assumption necessary.

Another part of the R&D measurement problem arises since firms were allowed to capitalize or expense R&D prior to January 1, 1975 (an October, 1974, ruling by the Financial Accounting Standards Board [18] now requires firms to expense R&D). Thus, in years prior to 1975 practices across firms could vary, making cross firm data less comparable.

The result of these two problems is potential errors in variables. For models in which R&D is the dependent variable this presents no serious problems; but, in models in which R&D is an independent variable, errors in variables can cause biased and inconsistent parameter estimates.

CHAPTER 3

DATA BASE AND PATTERNS OF JOINT VENTURE BEHAVIOR

As indicated in Chapter 1, diversity is an important aspect of JV behavior. Conflicting conclusions of earlier studies are partly due to the difficulty of isolating the diverse industry and firm-specific determinants of JV formations. In this chapter, the description of the data base once again highlights the complicated patterns observed within and across industries. Because of this diversity, several classification schemes are developed for later analysis.

3.1 The Data Base

Figure 3.1 provides a schematic representation of the two major data sources, and how they are tied together for empirical analysis. The widely used Standard and Poor's Compustat tape is the source for information on the individual corporation's R&D, sales, rate of return, cash flow, and industrial classification, among other variables. The other major source, consisting of 552 firms engaging in JVs, was developed for the Joint Venture Assessment Project (JVAP), a National Science Foundation (NSF) funded project run by Sanford V. Berg and Philip Friedman to study JV behavior.[1]

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[1] The Executive Summary of grant RDA 75-19064 contains a listing of JVAP research output. See [9].

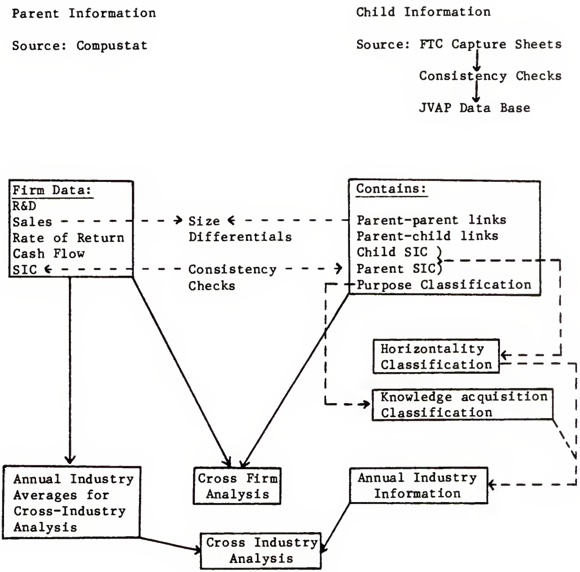

Figure 3.1

Data Bases for Joint Venture Analysis

Table 3.1

Number of New Joint Ventures, by Industry, 1966-1977
(Domestic and Foreign From FTC)

Major Industry Group of Joint Venture	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Total	218	171	169	203	223	244	275	245	127	77	105	115
Manufacturing	157	111	105	119	132	124	59	84	42	47	52	41
Food and Kindred Products	10	5	4	6	8	5	5	9	8	4	3	--
Tobacco Manufactures	1	1	--	--	--	1	--	2	--	--	--	--
Textile Mill Products	1	3	--	2	5	7	3	4	3	--	--	1
Apparel	--	3	2	1	1	--	--	1	2	--	--	1
Lumber Products, Except Furniture	--	--	1	1	4	1	--	1	--	1	--	--
Furniture and Fixtures	--	--	1	--	--	1	1	--	--	--	--	--
Paper and Allied Products	5	5	7	3	1	3	2	3	3	--	2	1
Printing and Publishing	2	1	2	4	3	2	1	2	--	--	1	--
Chemicals	46	32	27	32	27	21	11	20	15	13	11	7
Petroleum	10	4	3	7	5	5	--	2	1	--	--	2
Rubber and Plastics	6	3	1	4	6	5	--	1	2	1	1	1
Leather Products	--	--	--	1	--	--	2	1	--	--	1	2
Stone, Clay, Glass, and Concrete	8	3	2	3	8	4	1	2	6	2	4	4
Primary Metals	13	8	7	3	11	5	2	5	1	5	5	2
Fabricated Metal Products	16	2	8	3	8	5	3	7	1	1	2	3
Nonelectrical Machinery	15	18	16	13	20	25	7	6	15	5	9	4
Electrical Machinery	15	11	16	19	11	16	6	12	8	7	5	7
Transportation Equipment	2	2	3	15	8	10	7	5	3	4	6	4
Instruments & Related Products	6	8	5	--	3	6	4	3	3	4	2	4
Miscellaneous and Ordnance	1	2	--	2	3	2	4	1	1	--	--	--
Mining	24	25	22	21	17	32	3	9	1	4	9	8
Nonmanufacturing and Other	37	35	42	64	74	88	57	58	31	23	21	57
Unknown								91	23	3	23	9

Source: Bureau of Economics, Federal Trade Commission. Annual Statistical Reports on Mergers and Acquisitions.

Table 3.1 - continued

Note: No historical comparison can be made, since the formation of a new corporate entity was stressed beginning in 1972. Due to a lack of follow-up information, some ventures may never have been consumated.

Note: Since the annual Figures are subject to revision the totals may be off by several percentage points. For example, the November 1977 Report recorded 289, 247, 130, 82, 105 for 1972-1976, respectively. Also note that these numbers represented industry of the child. Most of this analysis has been conducted on the basis of parent industries.

Data collection efforts entailed approximately two man-years, primarily by the author. The data base developed for the JVAP, subsequently called the JVAP data base, was derived primarily from the Federal Trade Commission (FTC) capture sheets. Extensions to that data base have been accomplished as part of the dissertation.

The FTC capture sheets covered a broad range of international and domestic JV activity across all industries. The JVAP data base, however, only includes domestic manufacturing and mining JVs. The FTC's sources of information were public sources such as the Wall Street Journal, Standard Corporation Reports, Moody's Manuals, annual reports, etc. Within funding constraints, these same sources, particularly Moody's, were used for data consistency checks in creating the JVAP data base.

Table 3.1 presents the published FTC listing of JV activity, derived from the more detailed data capture sheets. The classification is by industry of the child. This scheme is in contrast to that used here, which is parent based to facilitate analysis of the causes and effects on the participating parents. Note that the number of JV formations has apparently declined over the past decade (partly due to changes in classification procedures by the FTC to be discussed shortly). Nevertheless, they are still significant factors in some industries, such as chemicals and the machinery/equipment industries. The analysis presented here covers 1964-1975, but the table presents updated data through 1977 for a more complete depiction of JV patterns over time.

3.2 Data Base Characteristics

The availability of data affects the type of analysis that can be performed. Some of the more important data base characteristics are listed below:

(1) JV as a Dichotomous Variable. Because of consolidated accounting statements and the sensitivity of such information very few data were obtained on the amount invested in JVs or revenues received from JVs. Consequently, analysis at the firm level is limited to entering JV as a dichotomous variable. In the cross-industry analysis, however, level and intensity measures will be used.

(2) Historical Data Unavailability Necessitates Cross-sectional Analysis. Compustat data for certain variables of interest, such as R&D data, are incomplete, particularly in earlier years. Such data limitations force much of the analysis to be cross-sectional in more recent years (1973 is often used).

(3) Large Firms Bias in Compustat. Compustat listing requirements prevent the inclusion of smaller firms. Thus, there is a large firm bias in the sample employed in analysis. This problem is reinforced by the limitation cited in (2). Generally, only larger firms in Compustat have R&D data reported. The study, therefore, is limited to the causes and effects of JV activity on large firms, omitting analysis of the causes and effects on small and medium size firms.

See Table A.1 for a more detailed representation of the data set employing Compustat firms relative to the JVAP data base.

(4) FTC Changed Reporting Requirements in 1972. In 1972 the FTC tightened its basis for inclusion of a JV in its data base. This break in procedure creates problems in time-series analysis. The cross-sectional models of firms' behavior are not affected, but the cross-industry models including time-series and cross-sections may be affected. This problem is mitigated to some extent because greater emphasis is placed on the cross-section results. Furthermore, the large firm bias may mean that the change in coverage does not affect the level and intensity measures used in the cross-industry analysis.

(5) Difference between FTC Listings and JVAP Data Base. There are differences in the number of identified JVs between the FTC listing (see Table 3.1) and the data capture sheets. This leads to a difference between the FTC listing and the JVAP data base. Some of the difference is explained by the focus here on domestic JVs only.

(6) Name Changes and Mergers May Cause Measurement Errors. Problems in identifying firms due to name changes, mergers, and liquidations cause potential errors in analysis. Name changes

can cause the inclusion of a JV firm in the nonJV set, or visa versa, causing errors in variables. Mergers can cause the characteristics of the firm to change. Thus, the characteristics of the firm at the time it entered into the JV may not be the same as those measured by Compustat's consolidated accounts at a later date. The assumption must be made that managerial preference or resistance to JVs does not change as a result of the merger. Liquidations simply cause the loss of observations. This, however, may be critical when observations are few. When possible, adjustments were made to reflect these changes.

(7) Use of SIC Codes Causes Problems. Standard Industrial Classifications (SIC) are used to identify industry groups for the cross-industry analysis. Problems arise commensurate with the use of SIC codes. The first problem stems from firms' diversification and from SIC codes based on historical classifications. The cross-industry analysis uses primary SIC codes as the basis for identifying industry groups. These primary SIC codes vary across data bases. Since several data bases are used, some judgement is required to identify the appropriate SIC of a firm.

The second problem stems from the inability to identify the SIC of some firms, which is exacerbated by the involvement of small firms in JVs. The cross-industry analysis employs measures of JV activity based on the industry juxtaposition of

the parents and parent-child (i.e., horizontal vs. nonhorizontal). Missing SIC codes for some firms causes fluctuations in sample sizes, which increases the potential for bias from missing observations.

3.3 Data Classification Schemes

The following classifications will be employed to capture diversity in behavior: (1) size of parent firm, (2) purpose of the JV, (3) parent-parent horizontality, and (4) parent-child horizontality. Classification (1) applies principally to the cross-firm analysis; classifications (2), (3), and (4) apply principally to the cross-industry analysis.

3.3.1 Size of Parent Firm

As noted in Section 3.2, data limitations restrict the analysis to relatively large firms. This section substantiates the assertion of size bias in the sample by considering the proportion of large and small firm participations in JVs and by considering the prevalence of large-small pairings.

Table 3.2 provides evidence of small firm involvement in JV activity. It shows the number of firms falling into various size classes for 943 participations (e.g., a JV formed by three parents counts as three participations). The table supports the observation of large and small firm involvement in JVs. If less than $50 million is arbitrarily chosen as the definition of small, then 54% of the 943 participations involved small firms. Thus, Table 3.2 indicates that

Table 3.2

Size and Distribution of JV Participations
(Compustat and Non-Compustat Firms)

Mean $212.82 million in sales
Median $39 million
Mode $15 million

Size (in $ millions)	Number of Participations	Size (in $ millions)	Number of Participations
less than 1	64	-150	73
1.01 -2	37	-200	56
2.01 -3	26	-250	37
3.01 -4	23	-300	18
etc. -5	22	-350	19
-6	19	-400	13
-7	19	-450	9
-8	13	-500	14
-9	9	-550	4
-10	20	-600	7
-20	103	-650	4
-30	55	-700	2
-40	42	-750	5
-50	31	-800	2
-60	24	-850	2
-70	22	-900	5
-80	23	-950	1
-90	22	-1000	39
-100	23	greater than 1000	36

Table 3.3

Relative Sizes of Parents for Joint Ventures When Only Two Parents Are Involved (1964-1975) And Size Data Are Available For Both Parents

Size Multiple[a]	Number of JV'S	Proportion	Cumulative Proportion
5X	37	.204	.204
4X	23	.126	.330
3X	8	.044	.374
2X	16	.088	.462
1X	98	.538	1.000
TOTAL	182	1.000	

[a] Size multiple is computed by dividing the small firm's size into the large firm's size.

the proportion of large and small firms engaging in JVs is about equal.

Table 3.3 provides evidence on the prevalence of large-small pairings. The table considers the relative sizes of a sample of JVs when only two parents are involved. JVs with more than two parents are excluded since it is difficult to categorize relative sizes if there are more than two parents. The sample represents 182 out of 581 JVs with two parents. If one parent 3 times larger than its coparent is taken as an indication of large-small pairings, then 37.4% of JV activity can be so classified. This 37.4%, however, is likely to be conservative. An additional 89 JVs in which one parent had sales over $200 million and the other had missing data are probably large-small pairings. That would raise the percentage to 57.9%. The above observations support those of Hlavacek, Dovey, and Biondo [27] and indicate that large-small pairings may be quite prevalent.

As in any analysis of diverse phenomena, care must be taken in interpreting empirical results. This study primarily analyzes large firm JV behavior and the results for large firms may not apply to small firms. A more dramatic case for differences between large and small firm motivation is presented in the next chapter.

3.3.2 Classification by Purpose of the JV

In the cross-industry analysis, three sets of JV incidence measures, sometimes converted to intensity measures, are used to

measure how participation in JVs affects industry average profitability and industry average R&D expenditures. Table 3.4 presents these three sets of incidence measures for 19 industry groups. Each set is constructed from the same underlying data base, though sample size for each set varies.[2] Thus the table entries must be considered in pairs (e.g., total JV activity for the sample can be found by summing JV1# and JV2#). This section discusses the construction of the first set of measures appearing in the table, JV1# and JV2#; the construction of the remaining two sets of measures, composed of JV3# through JV6#, is discussed in the next two sections.

The first set of incidence measures appears in the columns with the knowledge acquisition heading and captures the technological characteristics of the child. It is assumed at this point that knowledge acquisition is important for technologically oriented JVs, but not important for nontechnologically oriented JVs. This proposition is tested in later chapters. Note that the data in the table represents the level (incidence) of JV activity over the entire period under examination, 1964-1975; the table does not show the year-to-year incidence measures used in statistical analysis. Those numbers appear in the appendix, Table A.3.

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2 Note, for example, the metal mining industry with sample sizes of 63 versus 60 versus 35 for the three sets of incidence measures. Such sample size variation results from missing SIC codes, which are required for the construction of the two sets of horizontality indexes (see Section 3.2, number 7).

This classification, which is taken from Berg and Friedman [10] and is used to examine the effects of JV activity on industry average R&D expenditures, divides JVs into two groups of incidence measures (representing the number of JV participations in each industry): (1) parents involved in technologically oriented JVs (JV1#), and (2) parents involved in nontechnologically oriented JVs (JV2#).

The classification is constructed from the FTC capture sheets. The first step involved judgements about the stated purpose of each JV. Each JV was classified into the following categories (purposes): (1) R&D, (2) exploration and drilling, (3) production, (4) marketing, (5) service, or (6) construction. Multiple classifications can occur; for example, a JV could have been formed to produce and market a product.

From the above categories, participations were then divided into the technological or nontechnological classifications. The allocation rule was: (1) classify as technological (JV1#) all JVs whose stated purpose was R&D, or some combination of R&D with other categories (190 JVs); (2) classify as nontechnological (JV2#) all JVs whose primary stated purpose was marketing, construction, or exploration and drilling (213 JVs); (3) allocate as half to JV1# and half to JV2# all JVs whose primary stated purpose was production or service (305 JVs). The half-half rule was adopted since production and service JVs were judged to contain both technological and nontechnological components and a decision rule which simply allocated

Table 3.4

Three Classifications of Joint Venture Participations:
By Parent Industry (1964-1975)

Industry Description	By Purpose: Knowledge Acquisition		By Horizontality: Parent-parent		Parent-Child	
	Important (JV1#)	Unimportant (JV2#)	Horizontal (JV3#)	Not Horizontal (JV4#)	Horizontal (JV5#)	Not Horizontal (JV6#)
Metal mining	14	49	25	35	21	14
Extraction of petroleum & gas	4	19	6	12	10	4
General food	13	11	6	11	2	13
Textiles	7	7	-	-	-	-
Basic chemicals	47	42	13	56	19	49
Ethical drugs	12.5	4.5	4	12	2	10
Paint, agricultural chemicals, NEC	7	7	4	7	4	7
Petroleum refining	48.5	110.5	64	65	6	86
Glass and nonmetallic containers	9	4	-	13	2	10
Cement, clay, gypsum, NEC	6.5	12.5	-	-	3	18
Iron and steel	5	16	4	17	6	16
Nonferrous metals	13	25	4	27	6	24
Metal containers & fabricated metals	7.5	8.5	-	20	-	12
Nonelectrical machinery, geneal	12	7	4	26	4	13
Nonelectrical machinery, specialty	12.5	2.5	-	22	-	14
Electrical machinery	18.5	6.5	4	30	5	19
Electronics, communications & computers	35	13	24	48	32	17
Autos and auto parts	30.5	8.5	12	34	8	27
Aircraft and transportation equipment	22.5	8.5	2	33	4	24
Scientific instruments and measuring devices	17.5	3.5	-	10	1	16

to JV1# or JV2# seemed less appropriate. The half-half rule is based on the judgement of Drs. Berg and Friedman, who closely examined the technological-nontechnological characteristics of a sample of approximately 150 of such JVs.

It is sometimes more useful to represent the JV measures in relative terms (i.e., as intensity measures which represent JV participations relative to the number of potential participations). These industrial intensity measures are calculated by dividing the incidence measures, JV1# and JV2#, by the number of firms in the industry. The number of firms in the industry is represented by the number or Compustat firms in the respective industries with available sales and rate of return data. This calculation is done for each industry for each year.

The intensity measures, rather than the incidence measures, are sometimes used since the intensity measures remove bias due to inter-industry differences in the number of firms. That is, industries with more firms have more potential parent participations than industries with fewer firms, all else constant. Also, the intensity measures are more consistent with models adjusted for heteroscedasticity when that adjustment becomes necessary. The number of firms in the Compustat industry samples are used as divisors, rather than the number of firms in the industries, because the JV sample is based on Compustat and, therefore, greater consistency in the two numbers obtains.

Note that the data in the knowledge acquisition columns

indicate purpose and industry diversity. Though some aggregation of purpose has been done, one can still observe purpose diversity, since significant portions of JV activity fall into the two separate classifications. Furthermore, it is expected that technologically oriented JVs and nontechnologically oriented JVs are formed to accomplish substantially different purposes, different enough that the effects on profitability and R&D expenditures from the two classifications may also differ substantially.

Industry diversity is also illustrated. Consider, for example, the variation in the levels of JV activity between petroleum refining and textiles. The causes of such variation between industries merits attention and is treated in the cross-industry analyses of Chapters 5, 7, and 8.

3.3.3 Classification by Parent-parent Horizontality

As Pfeffer and Nowack [46] and Mead [41] note, the market structure relationships between the parents and between the parent and child may be important determinants of the impacts of JVs on industry performance. For example, collusion is more likely to occur the greater the product market overlap of the parents or parent and child. Two relationships can potentially influence performance: horizontal relationships, where parents operate in the same market, and vertical relationships, when parents operate in different markets but where such markets are interconnected through supply channel linkups. Horizontal relationships, however, are the only ones examined here.

Two sets of JV incidence measures, sometimes used in the form of intensity measures, are employed to capture the effects of horizontality.[3] The first represents parent-parent horizontality. The second, discussed in the next section, represents parent-child horizontality.

Table 3.4, columns labeled JV3# and JV4#, presents the incidence of JVs classified as parent-parent horizontal (JV3#) and parent-parent nonhorizontal (JV4#). Horizontality is measured at the 2 1/2-digit SIC level, the construction of which is shown in Table A.2 in the appendix. This level of measurement should yield better results than those obtained by Pfeffer and Nowack [46], who measured horizontality at the 2-digit SIC level. For example, a pharmaceutical firm and a basic chemical firm operate in different markets, but Pfeffer and Nowack classified these industries together. However, the Pfeffer and Nowack means of classification is not directly comparable to the ones used here, since their classification is child based (e.g., they would credit a chemical JV between two petroleum firms as horizontal in chemicals, the classification used here would credit the horizontality to petroleums). Pfeffer and Nowack also took secondary product lines into account when determining market overlap. The assignment used here is more useful for determining the impact of JVs on performance in parent industries.

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[3] The Berg-Friedman studies did not explore the horizontality issue.

As with the technological-nontechnological measures, the analysis sometimes employs intensity measures rather than incidence measures. The means of construction is the same. Table A.4 in the appendix shows the year-to-year incidence measures used in statistical analysis.

The parent-parent horizontality columns in Table 3.4 show a result that strikingly contrasts with one observed by Pfeffer and Nowack [46]. Under their method of classifying horizontality, they observed a prevalence of horizontal relationships between firms and cited such relationships as a point of concern for antitrust authorities. Table 3.4, with but few exceptions, shows just the opposite, a prevalence of nonhorizontal relationships.

3.3.4 Classification by Parent-child Horizontality

The final classification scheme for cross-industry analysis involves parent-child horizontality.[4] Again, the purpose is to capture the effects of market structure relationships, but this time measured between the parent and child. Table 3.4, columns labeled JV5# and JV6#, presents the incidence of parent-child horizontal JVs (JV5#) and the incidence of parent-child nonhorizontal JVs (JV6#). The year-to-year incidence measures appear in Table A.5. The incidence measures are sometimes converted to intensity measures for statistical analysis, as before. The result of a greater prevalence of nonhorizontal JVs also obtains for the parent-child measures, again in contrast to Pfeffer and Nowack [46].

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4 Horizontality is measured at the 2 1/2-digit SIC level. A further discussion appears in the Appendix.

CHAPTER 4

THE CAUSES OF JV ACTIVITY: THEORETICAL CONSIDERATIONS

Because of the diversity of JV behavior, several possible motivations may stimulate JV activity. This chapter evaluates some of these possible motivations from a theoretical perspective. The chapter first considers conditions which are conducive to JV formations that relate to firms' relative opportunity sets and possession of resources. Then, potential influences from uncertainty and project risk are considered. Finally, since a number of JVs are technologically oriented, potential influences from project timing are considered. These considerations raise issues for subsequent empirical analysis, and these issues are discussed in the last section of the chapter.[1]

4.1 JV Behavior, Firms' Opportunity Sets, and Firms' Resources

A primary cause of JV activity appears to stem from differences in firms' opportunity sets and differences in the resources at their disposal, thereby creating different comparative advantages. Factors which create differences in opportunity, such as specialized knowledge or ownership of scarce natural resources, can be important

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[1] Though mergers may be an important alternative to JVs, the issue of JV versus merger is neglected.

in a JV decision. Also, other resources, such as preexisting distribution channels or ability to finance large projects, can be important inputs. Numerous examples of such input differences can be found in the JVs formed between 1964 and 1975. Some firms, for example, owned land containing scarce natural resources while others had drilling or mining capabilities; some firms held patents while others had distribution channels.

Barriers to entry may be an important determinant of JV activity. Such barriers may reflect differences in opportunity sets and resources. Bain [4], Scherer [55], and Mansfield [37], among others, cite preexisting distribution channels, patents, and scarce natural resources as barriers to entry. Large capital entry requirements, possibly necessitating the involvement of a large firm, may be important for some JVs. The existence of these entry barriers, particularly when the inputs of the respective parents overcome different entry barriers, can lead to JV superiority over going it alone.

4.2 Implications for JV Behavior from Uncertainty and Project Risk

Differences in opportunity sets and resources can lead to differences in firms' ability to undertake risk. This may be particularly true when large, small pairings are involved. Differences in firm size, for example, often implies differences in firms' diversification, which can affect risk-taking behavior. A second possible influence can stem from different levels of risk aversion. Differences in risk aversion can be important determinants of JV activity through effects on negotiations and relative cost contri-

butions. Finally, possible synergistic effects, relating to risk reduction, may stem from different opportunity sets and resources.

For risk-related arguments to apply, some evidence of high risk for JV projects is necessary. Table 3.4 provides such evidence. The table indicates a large proportion of technologically oriented JVs. Technologically oriented projects, encompassing both technological and marketing risks, entail high risk. Some nontechnologically oriented projects, such as exploration and drilling or market entry projects, can also entail high risk. For exploration and drilling projects, for example, high risk is reflected in the 16% success rate of wildcat wells [16].

Diversification. When project risk is high, standard diversification arguments may apply. Particularly in R&D and exploration and drilling projects, the correlation with other such projects and with economic activity in general can be expected to be close to zero. Markowitz [40], Tobin [58], and Sharpe [56], among others, show that zero correlation implies significant risk reduction through diversification.[2]

The motive of risk reduction through diversification, however, may be one-sided when large-small pairings are involved. Evans and

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2 In the Capital Asset Pricing Model, diversification provides a means of eliminating unsystematic risk, such that decisions can be made based on systematic risk alone. For an undiversified firm, however, unsystematic risk may still be an important consideration in evaluating a project depending on managerial objectives and market imperfections. For a diversified firm, zero correlation implies a zero beta coefficient and such a project, when combined into the firm, can reduce even systematic risk.

Archer [17], with respect to securities, and Wippern [60], with respect to large oil firms, show that diversification reduces risk by only small amounts once a certain level of diversification is achieved. Thus, if a large firm has reached such a level, and if the JV is small relative to the firm's size, then diversification arguments may not apply.[3] For such large firms, differences in opportunity, such as access to scarce resources or knowledge, would more likely be the motivation to form a JV, since scarce resources or knowledge would be needed inputs into their production processes. Risk reduction may, however, be more generally expected to play an important role in the decisions of small firms. An individual project, for a small firm, may significantly increase bankruptcy risk.

Different Levels of Risk Aversion. Firms' diversification, financial structure, and size (possibly reflecting other factors such as distribution channels or financial capabilities) can affect the level of risk aversion of firms' managers. Firm size, as a reflection of other factors, may be particularly important in this respect. For example, a project, if entered alone, may materially affect the riskiness of a small firm; on the other hand, the project may have little impact on the riskiness of a large firm. Thus, the small firm can be expected to exhibit greater risk aversion than the

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3 There are some obvious exceptions, such as the Alaska Pipeline or telecommunications satellites. For such JVs, risk may be substantial enough to justify risk reduction motives even for large firms.

large firm. Since a large proportion of JVs involve large-small pairings, the influence of risk aversion, possibly reflected through size, may be important.

Differences in risk aversion make possible differences in the relative cost-benefit contributions of the parents. In a JV project, differences in the levels of risk aversion can lead to the less risk averse firm, presumably the larger firm in a large-small pairing, paying a risk premium to the more risk averse firm in order to enter the project.[4] Thus, differential levels of risk aversion can be an important determinant of JV activity through effects on negotiations and cost contributions.[5]

Synergism and Risk Reduction. The final possible influence to be discussed relates to risk reduction through synergism. Since different inputs are provided by the parents, synergistic effects through the JV can alter the project's risk characteristics and costs. A small firm, for example, might avoid significant marketing

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4 In an article on merger activity, Gort [21] cites valuation discrepancies as a potential motivation for mergers. His argument is similar to the one proposed above since different levels of risk aversion can result in valuation discrepancies. Furthermore, different levels of risk aversion provides an explanation for valuation discrepancies.

5 Another, more simple explanation can be used to explain large-small pairings. If two small firms join together, the combination could be weak. Possible antitrust action or rivalry may defer two large firms from joining together. Thus, the large firm will choose a smaller partner to avoid antitrust problems or to protect its specialized knowledge from strong competitors; the small firm will choose a larger partner for the large firm's financial and marketing strength.

risks and costs associated with setting up distribution channels if the large firm supplies that input; the large firm might avoid significant project development risks and costs if the small firm's technology is more advanced.

An important aspect of JVs, if synergisms occur, is lower capital costs than could be obtained through the capital markets.[6] Furthermore, since capital markets are circumvented, the relative financial positions of firms may be an important determinant of JV activity. In the sense that a smaller, capital scarce firm possessing specialized knowledge chooses JV over the capital markets, it will want a coparent with adequate financial capabilities to make it possible to circumvent the capital markets (this also helps explain why small-small pairings are less likely to occur).

4.3 Implications for JV Behavior from Project Timing

The Scenario. Section 3.3.1 pointed out that large-small pairings often occur. Table 3.4 indicated a large proportion of technologically oriented JVs. The data base, however, does not indicate the interdependence of these two observations; but, as is suggested by Hlavacek, Dovey, and Biondo [27], the conditional probability of a technologically oriented JV given a large-small pairing can be expected to be quite high.

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6 Market imperfections, such as the higher flotation costs for smaller issues pointed out in Archer and Faerber [1], may also influence the JV decision and make circumventing the capital markets more desirable.

This interdependence may stem from the small firm's comparative advantage in R&D productivity, as indicated in the R&D literature review. This evidence suggests that we can expect the small firm to be the primary supplier of technological inputs. The large firm, on the other hand, can be expected to be the primary supplier of capital and other capital intensive inputs such as distribution channels.

Application of Scherer's model. As noted in Section 2.1, Scherer [54] has developed a model which deals with a situation in which R&D rivalry exists between firms. The actions of one firm are determined by its own development of a project and by the potential developments and introduction of its rivals. Both of these aspects in turn determine the expected discounted revenues from the project, the costs, and the juxtaposition between revenues and costs (see Section 2.1).

To see how Scherer's model applies, consider the response of a large firm when confronted with the prospect of a JV. For illustrative purposes, suppose the small firm approaches the large firm with some new R&D development which is developed beyond that which the large firm has accomplished. This condition implies that the small firm's cost function C_S (R&D costs only) is below the large firm's cost function C_L.

What can we expect the large firm's reaction to be? Figure 4.1 presents three possible situations in panels (a), (b), and (c). Panel (a) presents a graph, which represents two superimposed graphs,

of a large firm and a small firm in the process of developing the same project. This graph assumes no special knowledge on the part of either firm of the other's developments (i.e., both firms may, or may not, know of the other firm's interest in the project, but do not know the extent of development by the other firm). For both firms, the project is feasible since V_L (the expected present value of revenues minus costs, except R&D costs, as in Section 2.1) is above C_L (R&D costs) for the large firm and V_S is above C_S for the small firm (V_S and C_S similarly defined). Note that project feasibility for the small firm is a quite reasonable assumption, following from the assumption that the small firm's principal contribution to the JV will be their R&D development; however, in the absence of the JV prospect, the large firm may be planning to withhold introduction until a later date when profitability would be still greater.

One other assumption is also implied in the graph in panel (a): V_L above V_S could represent capital and marketing limitations on the small firm which would restrict their market penetration and thus potential benefits.

Now, consider panel (b). Here, it is assumed that the small firm approaches the large firm with the JV prospect, thus informing the large firm of the extent of the small firm's development. The large firm's benefit function (V_L in panel b) should shift downward and take on a steeper slope from potential rivalry, as suggested by Scherer [54]. Essentially, if the large firm turns down the JV

prospect, the small firm can take its innovation elsewhere, perhaps to a competitor of the large firm. The large firm can choose to ignore the JV prospect, in which case the increased rivalry should speed up introduction, T'_L, but with a lower rate of return (YX/XT'_L instead of SR/RT_L). V'_L could also shift below C_L causing the large firm to abandon the project.

The large firm, on the other hand, could choose to enter into the JV. In this case, the benefit function, V'_L, represents the benefit function of the JV, V_{JV}, and the small firm's cost function represents the cost function of the JV, C_{JV}. The distance VZ represents the bargaining range for the two firms. Even if the small firm demands a larger portion of the shared returns relative to their dollar contribution, the large firm can still gain.

The model is obviously simplified, the JV need not result in an introduction time $T'_L = T_S$, as is illustrated. It is possible that the JV may result in a delay in introduction, or through overcoming barriers to entry may speed up introduction to some time less than T_S. However, it is expected that introduction time will be less than or equal to T_S, since the small firm's cost function is not likely to be parallel to C_L, but steeper in the initial periods. Thus, it will likely choose a partner who is amenable to earlier introduction.

One other possible situation merits attention. Panel (c) presents the case in which the large firm's benefit function, V_L, is below its cost function, C_L. Again, the small firm's technological developments suggest V_S is above C_S. With the introduction of a JV we may get a reverse rivalry effect (i.e., V_L shifts upward and

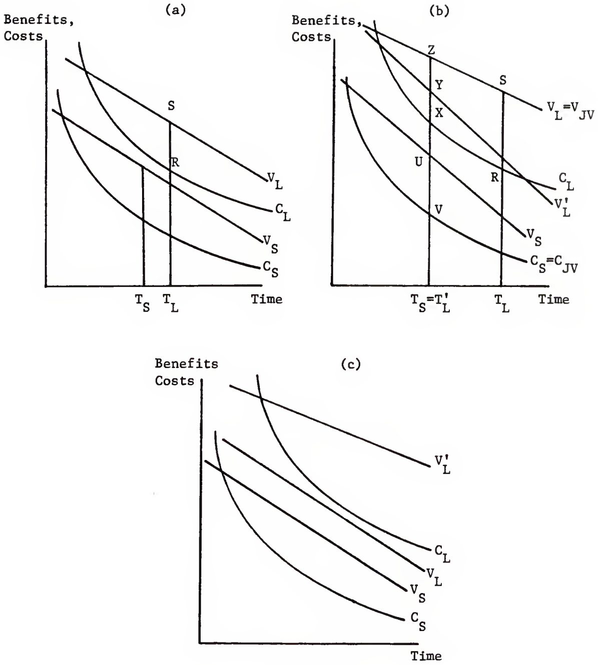

Figure 4.1

Benefits, Costs, and Timing of Product Introduction with JV

flattens to V'_L). In this case the bargaining position should be greater for the small firm. Again, both firms can gain from the JV.

Section 4.2 proposed two potential influences on JV behavior which can have an impact on the current model: (1) risk reduction and (2) different levels of risk aversion.

Potential risk reduction can affect the model by raising V_{JV} above V_L in panel (b), thus making a JV an even more attractive alternative. We can conceptually divide R&D risks into technological risk, those associated with uncertainty about developing a useable product, and marketing risk, those associated with the selling and marketing of the product. A JV to the large firm can significantly reduce the technological risk (assuming the small firm supplies technology) and perhaps some marketing risk as well (marketing risk, for example, may be reduced because of earlier identification of product uses). Such risk reduction may cause V_{JV} to be above V_L from a lower risk premium being imputed in the discount rate. The implication is an even wider bargaining range for the two firms. The risk reduction aspect of JVs, then, may be quite important for technologically oriented JVs, regardless of the other risk reducing activities of the firm.

Different levels of risk aversion may also be important in determining the bargaining range. The expected lower risk aversion of the larger firm, relative to the small firm, would imply a willingness on the part of the larger firm to accept a lower share of revenues in relation to their cost contribution.

4.4 Implications for Subsequent Empirical Analysis

The next chapter turns from theoretical considerations of the causes of JV activity to empirical examination. The considerations of this chapter, however, yield some important implications about what we can expect to find in the empirical work.

First, since opportunity set differences may be an important determinant of JV activity, patterns across industries may differ. As a result, the cross-firm analysis should be disaggregated as much as possible. Further, the effects from opportunity set differences, possibly reflected through barriers to entry, can be analyzed for industry effects.

Second, since project risk may be an important determinant of JV activity, the analysis should include differences in the type of JVs. This is done through the cross-industry analysis which employs the technological, nontechnological characteristics of JVs. Though desirable, the cross-firm analysis will not treat differences in the purposes of JVs because of insufficient observations. The potential impact from firms' R&D intensity can, however, be examined to test for the importance of the parents' technological inputs into the JV.

Third, the role of differential levels of risk aversion again points out the importance of firm size. It is important, therefore, to recognize that only large firms are analyzed. Firm size can also be entered directly as an independent variable to examine the direct effect of firm size on JV activity. Possible synergisms imply the

potential importance of financial influences on the decision to form a JV. Since JVs circumvent the capital markets, the financial characteristics of the parents may be important. These are examined principally in the cross-firm analysis.

Fourth, the effect on timing of introduction of a project can materially affect the decision to form a JV. This, however, is not examined directly in the empirical analysis of the causes of JV activity; rather, it is examined in Chapters 6 and 8, which deal with the effects of JV on a firm's R&D spending. Particularly, in Chapter 8, the issue of R&D rivalry is addressed in cross-industry analysis.

CHAPTER 5

THE CAUSES OF JV ACTIVITY: EMPIRICAL EXAMINATION

This chapter empirically examines the causes of JV activity. Models at both the firm and industry levels are estimated. At the firm level, a probit model of the determinants of JVs is estimated. The probit model is used since observations on JVs are dichotomous. At the industry level, a regression model which pools cross-section and time-series observations is used to examine the determinants of the level and intensity of JV activity. The cross-pooled models are estimated for two classifications of JV activity: technologically oriented JVs and nontechnologically oriented JVs.

Since the examination is restricted to large firms only, it is hypothesized that the determinants of large firm JV activity is related primarily to the inputs they supply and secondarily to the inputs they derive from their coparent. Following from the discussion in the previous chapter, it is assumed that the firms examined can be characterized as receivers of technological inputs and suppliers of financial and marketing capabilities, except in the case of firms engaged primarily in the acquisition and fabrication of natural resources. Furthermore, the investment opportunities facing the firm or industry may act as a determinant of JVs through their effect on the firms' other alternatives. Thus, a proxy for investment opportunities is included in subsequent analysis. Investment

opportunities, however, are expected to be more important as a determinant of interindustry difference in JV activity than as a determinant of cross-firm differences within an industry.

5.1 Model Variables: Cross-firm Model

To capture the characteristics of firms which engage in JVs, relative to those which do not, proxies are chosen to represent each of the aforementioned characteristics. The following discussion presents the proxies chosen along with which characteristic they are expected to explain.

Three financial variables are used in this analysis. As in Edström's [15] Swedish cross-industry study, current assets/current liabilities (CR) is used as a liquidity index representing financial strength. He found this variable to be slightly correlated with industrial JV propensities. He also introduced measures of long term debt paying ability, but the results for this variable were uneven. Here, the debt-equity ratio (DE) is used as an index of corporate leverage. Such leverage represents corporate strength up to a point, beyond which risk of bankruptcy begins to become significant. After-tax rate of return (RR) on investment is used as the third financial variable. The expected signs for the three variables are unclear. While a smaller partner might seek a coparent with financial strength, it may be able to drive a better deal with a large firm that is strong in absolute terms, but weak relative to others in the same industry. Reinforcing the latter expectation would be the

likelihood that relatively weak financial conditions (possibly due to over-aggressiveness) would lead a large firm to search out external opportunities to which it could apply its managerial and physical resources. In our view, empirical tests across firms are more likely to pick up the impacts of such variables since Edström's industry averages could mask the true relationships. He found financial strength to be positively related to propensity to engage in JV activity, yet a negative relationship is quite plausible.

Size of the firm, as measured by the log of sales (Log S), is expected to be positively related to JV propensity. Boyle [11] viewed JVs as facilitating the creation of market power, although size could also be a proxy for the number of activities for which there are potential pairings with outside organizations. Certainly, a smaller firm would seek the marketing, production, and financial strength associated with a large firm. Average size of firm could be interpreted as a barrier to entry variable at the industry level. Gort [21], for example, argues that the frequency of mergers will increase with entry barriers, since the latter allow valuation discrepancies to exist. At the firm level, firm size may represent scale economies or distribution know-how.

Capital growth ($\dot{K}/K$) of the firm could represent investment to meet substantial commercial opportunities in the industry. If firms in an industry are engaging in a relatively high proportion of horizontal JVs (where parent and child are in same industry), the capital

growth variable would be expected to be positively related to JV initiations across firms. Furthermore, since JVs are one form of investment, relatively rapid capital formation would be expected to be positively related to JV formations. Gort [21] found merger incidence to be positively related to industrial sales growth, which he explained in terms of growth stimulating both valuation discrepancies and their discovery. However, JVs could be a substitute for internal investment, leading to a negative relationship. The net impact across firms is unclear. Across Swedish industries, Edstrom found production growth to be a relatively unimportant factor influencing JV initiations, although Gort found industry employment growth to be a significant determinant of U.S. mergers.

Technological expertise is represented by firm's research and development expenditures divided by sales (RD/S).[1] If the other (perhaps smaller) firm is the technology supplier, the large firm's R&D intensity may be an insignificant factor. In fact, the large firm could view knowledge acquired via JVs as substitutes for internally acquired know-how, which would result in a negative relationship. Again, the net impact across firms is unclear from the analytic model.

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1 Gort used technical personnel ratio as a proxy for technological change in his analysis of merger determinants: the correlation coefficient between industrial merger rates and the personnel ratio was .737.

5.2 The Statistical Model

Since the decision to engage in a JV is dichotomous, the choice of statistical model is limited to those with qualitative dependent variables. The model chosen is the probit model. Probit models, among others, allow us to interpret the dependent variable as the conditional probability of a firm entering a JV, given the set of aforementioned characteristics. It employs a transformation of the independent variables into a cumulative probability function.[2]

The probit model employed is:

$$(1) \quad P_i = F(b_0 + b_1\ CR + b_2\ RR + b_3\ DE + b_4\ \text{Log}\ S + b_5\ \dot{K}/K + b_6\ RD/S)$$
$$= F(JV_i)$$

where:

P_i = the probability of a JV occurring for the i^{th} firm, and

F = cumulative probability function.

We hypothesize that JV_i is a linear function of the individual characteristics in (1), i.e.:

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2 The logit model, which uses the logistic probability function rather than the normal, would suit the current purpose as well. Experience with these two models, however, indicates that results are not very sensitive to the choice between the probit and logit model.

The linear probability model and discriminant analysis are also possibilities with dichotomous dependent variables. The linear probability model, however, can generate probabilities outside the 0, 1 interval. Discriminant analysis does not lend itself to probability interpretations and is thus less desirable. The model development is adopted from Pindyck and Rubinfeld [48].

(2) $JV_i = b_o + b_1\ CR + b_2\ RR + b_3\ DE + b_4\ \text{Log}\ S +$
$b_5\ K/K + b_6\ RD/S.$

In addition, we assume that associated with each firm is a critical value JV_i*. The critical value allows us to describe an explicit criterion for predicting JV behavior:

(3) if $JV_i > JV_i*$, a JV should occur,
if $JV_i \leq JV_i*$, a JV should not occur.

The probit model assumes that JV_i* is a normally distributed random variable, so that the probability that JV_i* is less than (or equal to) JV_i can be computed from the cumulative normal probability function. The cumulative normal function is written as follows:

(4) $$P_i = F(JV_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{JV_i} e^{-S^2/2}\ dS, \text{ where } S = x-\mu/\sigma$$

The solution procedure entails solving for maximum likelihood estimates of the coefficients in (2). Differentation of (4) yields a set of nonlinear equations that can be solved using an iterative technique.

5.3 Results of Cross-firm Tests

The sample consists of 368 observations taken from the Chemicals (SIC 28), Petroleum Refining (SIC 29), Metals (SIC 33), Nonelectrical Machinery (SIC 35), Electrical Machinery (SIC 36), and Transportation

(SIC 37) industries. For estimation purposes, these industries are aggregated into 3 groups: Chemicals, composed of SIC 28; Resources, composed of SIC's 29 and 33; and Engineering, composed of SIC's 35, 36, and 37. Table 5.1 presents the number of firms, as well as the number of firms initiating JVs in each group.

Some aggregation was necessary since industries other than SIC 28 and SIC 29 contained so few JVs that estimation was impractical. The aggregation used seemed to be the most plausible based on industry characteristics. Petroleum Refining and Metals, the resources group, are oriented towards the acquisition and use of natural resources and are expected to be involved in resource acquisition JVs. Nonelectrical Machinery, Electrical Machinery, and Transportation are primarily based on science and engineering technologies

Table 5.1

JV Initiations by Firms, 1971-1973

Industry Group	SIC(s)	Number of Firms	Number of Firms Starting JVs
Chemicals	28	67	12
Resources	29,33	59	15
Engineering	35,36,37	218	30
Totals		368	57

and are expected to be involved primarily in technologically oriented JVs. Chemicals, SIC 28, can stand alone since the number of JVs are sufficient for estimation purposes; chemical firms are expected to be involved in technologically oriented JVs. These expectations tend to be supported in Table 3.4 (knowledge acquisition columns). The analysis is limited to this set of industries, since other industries contain insufficient JV data in any one year or set of adjacent years to allow accurate estimation.

The data on the model's independent variables are taken from Compustat for the year 1973. The criteria for inclusion of a firm in the sample was complete data: 1973 was chosen because R&D data, the most limiting set of data in any year, tend to be more complete for 1973 than prior years.

The dependent variable JV, is a dummy variable such that:

JV_i = 1 if firm i participated in a JV between 1971 and 1973,

JV_i = 0 if the firm did not participate in a JV during this period.

The 3 year representation is necessary since 1973 JV observations are not dense enough for estimation purposes. Since causation in this model runs to JV from the independent variables, it would have been more natural to use 1971 data on the independent variables, but that would have resulted in significantly fewer companies.

The possible misspecification that arises from using 1971-1973 JVs with 1973 observations on the independent variables can be justified to some extent for reasons other than saving observations

if we view the model's independent variables as equilibrium values. Since the years 1971-1973 were not subject to wide business cycle fluctuations, as would occur if 1973-1975 were chosen, it is reasonable to expect 1971 and 1973 observations to exhibit relative stability vis-a-vis one another, making the equilibrium notion plausible. Therefore, 1973 observations should provide a good proxy for 1971 observations. The major exception that might occur would be in the capital growth variable, due to rising short-term interest rates over the 1971-1973 period.

Table 5.2 reports the results of the probit equations for the 3 industry groups, equations 1-3, and for all industries taken together, equation 4. The values in parentheses are t statistics and the log likelihood ratio is distributed χ^2 with 6 degrees of freedom, representing a test of goodness of fit similar to an F test in Classical Least Squares. The χ^2 distributed log likelihood ratio is significant at better than the 1% significance level for all four equations and therefore all equations produced reasonably good fits.

Size of firms, represented by Log S, is significant and positive in all four equations. For a small firm, which is a technology supplier, preexisting market shares and distribution channels can be expected to weigh heavily in their choice of a partner. This result confirms the role that size plays in JV activity as indicated by Boyle [11].

RD/S is positive for the Chemicals and Resources groups. For Chemicals, RD/S is very close to being significant at the 5%

Table 5.2
Probit Analysis of the Determinants of JVs

Equation	SIC(S)	Constant	CR	RR	DE	Log S	K/K	RD/S	Log Likelihood[b] Ratio
1	28	-7.82	-1.26	-10.09	3.66	2.54	17.56	28.75	35.82
		(-2.13)[a]	(-1.82)	(-1.45)	(1.57)	(2.40)	(1.83)	(1.64)	
2	29,33	-6.54	.594	-4.37	.237	1.34	7.81	43.07	17.69
		(-2.51)	(1.75)	(-.50)	(.33)	(2.98)	(1.25)	(1.42)	
3	35,36,37	-1.92	-.374	-5.72	.453	.825	.523	-5.59	42.95
		(-2.42)	(-1.66)	(-1.96)	(2.12)	(4.31)	(.18)	(-.77)	
4	28,29,33	-2.60	-2.22	-5.92	.427	.908	2.83	-2.63	76.47
	35,36,37	(-4.08)	(-1.37)	(-2.65)	(2.17)	(6.11)	(1.29)	(-.54)	

[a] Values in parentheses are t statistics.

[b] The log likelihood ratio is distributed χ^2 with 6 degrees of freedom.

Note: Sample sizes and SIC names appear in Table 5.1.

level.[3] For Resources, RD/S is significant at the 10% level. The remaining two equations produce insignificant results for RD/S. The general weakness of the RD/S variable suggests the technological inputs of the large firms are generally less important than other factors. Chemicals is a possible exception, though as already indicated the result for Chemicals is marginal.

The capital growth variable is significant only for Chemicals, although the impact is positive in all equations. Other studies suggest that entry barriers are significant in Chemicals. While portions of other industries in our sample also have significant entry barriers (such as in Steel or Petroleum Refining), there appears to be a fundamental difference. The Chemicals industry tends to have barriers to entry and rapid technological change occurring together, as is illustrated by the coefficients on RD/S and $\dot{K}/K$ both being significant. From this result, it appears that JV opportunities in Chemicals may be associated with a high technology, high barriers to entry combination.

As occurred with the other variables, financial variables presented a mixed picture across the industry groups, and stand in sharp contrast to Edström's results. In the Chemicals and Engineering

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3 Chemicals has 61 observations and 7 independent variables, including the intercept; thus, there are 54 degrees of freedom. The t statistic is 1.64. The closest corresponding table value is 60 degrees of freedom with a t value of 1.67.

groups liquidity (CR) is negative, significant at the 5% level, though marginal significance occurs for Engineering. Leverage (DE) is positive, significant at the 5% level for Engineering, and also positive, significant at the 10% level for Chemicals. This result could be taken to indicate that financial aggressiveness may be a desirable large firm characteristic from the partner's perspective.[4]

In Resources, only liquidity (CR) is significant from among the financial variables. It has a positive impact rather than negative, as occurred in Chemicals and Engineering. Leverage (DE) shows no significant impact. The interpretation is that high liquidity is the desirable financial characteristic for this group. As was evident in Table 3.4, technology supplying activities are less likely to characterize this group than the other two. Possibly, resource acquisition JVs may demand faster capital commitments than do technology based JVs, thus requiring greater liquidity on the part of the participants. Furthermore, large-small pairings may be less likely for this group.

The two remaining variables did not have much explanatory significance. The measure of profitability, RR, does not appear to be a determinant of JV activity except in the engineering group. The negative, significant sign for this group would be consistent with

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4 Since leverage can be considered a risk proxy, higher leverage may indicate financial aggressiveness in the sense of lower risk aversion. Furthermore, this result would be consistent with smaller, more risk averse firms looking for a larger, less risk averse coparent, as suggested in Chapter 4.

defensive JV activity under stiff R&D rivalry, perhaps generating a superior bargaining position for the small firm. The coefficient on the capital growth variable is only significant for Chemicals, supporting the role of industrial opportunities (and possibly value discrepancies) for this industry.

When all groups are taken together (equation 4 in Table 5.2) size, leverage, and lower profitability appear to be the major determinants of JV activity. Given the disaggregated results in equations 1-3, the relatively larger sample size of the engineering group probably dominates the combined results.

5.4 Industrial Determinants of JV Activity

The previous section focused on interfirm differences leading to JV activity for a limited number of industries. Interindustry differences are of interest as well. In addition, the examination across industries allows the inclusion of a broader spectrum of industries than was used in the cross-firm studies.

In the interpretation of the cross firm results for Chemicals, we suggested that a JV is more likely to occur when barriers to entry and rapid technological change are industry characteristics. These characteristics may be the major determinants of interindustry differences in the level and intensity of JV activity.

This hypothesis follows from the observation of large-small pairings, where the underlying basis of many JVs may be technology transfer from the small firm to the large, which supplies capital,

marketing, and production capabilities. Rapid technological change, as an industry characteristic, offers a more conducive climate to the small firm (i.e., the opportunity set is larger). Greater rivalry pressure will be exerted on the large firm, which should make such firms more aware of the importance of new products and more amenable to external acquisition of technology when the opportunity arises. In addition, barriers to entry may be the primary force that stimulates the small firm to look for a partner with capital or market power. These barriers to entry may occur through large capital requirements, production scale economies, or through necessary marketing channels.

Pfeffer and Nowak [46] placed great emphasis on industrial concentration as a factor inflencing industrial propensity for horizontal joint ventures. They concluded that JVs are used to coordinate pricing and other activities when market structure approaches the median concentration level, but that such formal linkages are not needed for coordination in highly concentrated industries. Berg and Friedman [8] found that when horizontality is defined in terms of parent-firm's industries, neither concentration nor deviation from median concentration was significant determinants of JV propensities across industries. Average firm size proved to be a significant factor affecting JV formations. In addition, the technological intensity of the JVs was shown to be dependent upon R&D intensity of the industry. Here, we expand the data base to further identify the determinants of technologically oriented JVs and nontechnologically oriented JVs.

Besides the considerations of technology and barriers to entry, performance variables may act as determinants of interindustry differences in JV activity. For example, lower average profitability for an industry may generate the need for shared capital requirements. At first glance, this circumstance would not seem to be very important, since it is difficult to imagine that large firms as a group cannot raise sufficient capital to meet their needs. Lower average industry profitability, however, may reflect poorer opportunity sets within an industry, which in turn may stimulate large firms to engage in new market entry ventures via JV. (See Asch and Seneca [3] for similar arguments regarding propensities for firms to collude.)

The measurement of the dependent variable takes on one of four forms. JV is measured by the level of JV activity and by the intensity of JV activity. Within these two classifications there is a technological, nontechnological split, as previously discussed in conjunction with Table 3.4. We define the four JV measures as follows:

JV1# = technologically oriented JV formations,

JV2# = nontechnologically oriented JV formations,

JS1 = technological JV formation intensity (JV1#/N_C),

JS2 = nontechnological JV formation intensity (JV2#/N_C), and

N_C = number of firms per industry as taken from Compustat.

Each index of JV activity is measured for each industry per year.

The intensity measures are calculated by dividing the number of occurrences, JV1# and JV2#, by N_C, the number of firms per industry in the Compustat sample. (See Section 3.3.2 for further discussion.)

Barriers to entry may come in several forms. Here size (log sales) is used as a proxy to capture effects from production scale economies and barriers to entry in financial requirements (see Hall and Weiss [25]). The log form is used since the models for JS1 and JS2 are specified in ratio form and the log form is more consistent than sales entered directly in a ratio form model (see Kuh and Meyer [34]). Secondly, a threshold effect on size can be expected, which is better represented by Log S. The expected sign is positive.

The significance of the coefficient on R&D intensity, RD/S, provides a test of the hypothesis that industries with greater technological opportunity will experience more JV activity. The expected sign is positive when JV1# or JS1 are the dependent variables, negative or insignificant when JV2# or JS2 are the dependent variables. Since JV2# represents nontechnologically oriented JVs, there is little reason to expect that their occurrences should be influenced by the technological base of the industry.

Two other variables are included in the industry model. A capital growth variable is used to capture industry demand growth. The variable is defined as industry capital expenditures divided by total assets, $\dot{K}/K$. The expected sign is positive since faster growing industries are presumably experiencing more technological and commercial opportunities than stagnant industries. The effect of

average industry performance is represented by one period lagged rate of return on investment, RR_{t-1}.[5] Past profitability is expected to impact on current decisions. The expected sign is negative for reasons expressed previously.

Table 5.3 presents the test results from the cross-industry models. The sample consists of 19 industries over the years 1965-1975. There are 209 cross-section, time-series observations. All observations on independent variables are industry averages. All, except log S, are represented as size weighted ratios.[6]

The model tested is:

$$JV_{it} = b_o + b_1 \text{ Log } S_{it} + b_2 \,(RD/S)_{it} + b_3 \,(\dot{K}/K)_{it} + b_4 \, RR_{i,t-1} + e_{it},$$

$i = 1, \ldots, I$ for industries,

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[5] Lagged rate of return (past profitability impacts on current decisions) may be the better specification in both the cross-firm and cross-industry models, though contemporaneous rate of return was employed in the cross-firm models. Contemporaneous rate of return (profitability), as well as contemporaneous debt/equity (leverage) and the contemporaneous current ratio (liquidity), were chosen to represent the firm's financial position at the time the decision was made, a ratio analysis approach. In retrospect, however, lagged variables might be more appropriate since lagged rate of return tends to be significant in the cross-industry models, while contemporaneous rate of return tends to be insignificant at the firm level. Since both contemporaneous and previous financial positions should affect investment decisions (JV decisions in this case), the appropriate lag structure was not clear at the outset of the analysis, leading to this possible specification error. Furthermore, the trend in financial position, represented by changes over time might further improve the specification and would appear to be a worthwhile pursuit in subsequent analysis.

[6] The industry level observations are industry averages. Size weighted ratios are calculated by dividing the sum of the numerator (e.g., sum of R&D expenditures) by the sum of the denominator (e.g., sum of sales), thus producing weighted averages.

$t = 1, \ldots, T$ for years 1965-1975.

This representation is used for all four dependent variable measurements.

The signs of the first three variables, Log S, RD/S, and $\dot{K}/K$ are positive and significant in both the level and incidence equations for technologically oriented JVs, equations (1) and (3). Log S and $\dot{K}/K$ are positive, significant for the nontechnologically oriented JV equations, equation (2) and (4), but RD/S is negative, significant for equation (2) and insignificant for equation (4). Therefore, it appears that firm size (perhaps representing barriers to entry) acts as a stimulus to any kind of JV, but the combination of relatively high expenditures on new technology with production-distribution scale economies only stimulates technologically oriented JVs.

Table 5.3
Cross-industry Determinants of JVs
(1965-1975)

Equation	Dependent Variables	Constant	Log S	RD/S	$\dot{K}/K$	RR_{t-1}	R^2	F
(1)	JV1#	-2.65 (-3.75)	1.31 (5.93)	36.96 (4.84)	13.96 (4.03)	-11.85 (- 2.92)	.24	16.61
(2)	JV2#	-2.18 (-1.84)	1.49 (4.01)	-23.96 (-1.86)	19.34 (3.41)	-10.55 (-1.54)	.17	10.84
(3)	JS1	-.128 (-4.47)	.064 (7.18)	1.37 (4.42)	.434 (3.17)	-.595 (-3.60)	.26	18.48
(4)	JS2	-.101 (-2.54)	.065 (5.27)	.045 (.10)	.655 (3.45)	-.694 (-3.03)	.20	12.93

Lagged rate of return has a negative, significant impact in all equations except equation (2), where RR_{t-1} is significant at the 10% level. In all other equations the significant of RR_{t-1} is at better than the 5% level. Therefore, lower past profitability for an industry will cause an increase in JV activity, regardless of type of JV. This result supports the view that firms facing lower profitability look for new markets where potential is higher.

5.5 Conclusions

The tests presented here employ single equation models, rather than simultaneous models. The equations are preliminary in this respect, although the omission of a simultaneous model treatment is not unusual in initial studies. Nevertheless, simultaneity may present a problem and work in this direction is needed.

In this study, we have looked at the cause of JV formations from the perspectives of interfirm and interindustry activity. The findings indicate that the probability that a large firm will engage in a JV increases with the firm's (1) size (representing preexisting marketing channels and reputation), (2) financial leverage and illiquidity (in Chemicals and Engineering industries), (3) liquidity (in Resource based industries) and (4) capital growth (in Chemicals).

Across industries a difference between technologically oriented and nontechnologically oriented JVs emerges. Technologically oriented JV activity increases with an industry's R&D intensity,

larger average firm size (though a threshold effect is postulated), more rapid capital growth, and lower profitability. Scale factors and capital growth also affect nontechnological JVs, but R&D intensity does not. Profitability impacts on nontechnological JVs are mixed, affecting nontechnological JV intensity but not the level of activity.

These results conflict with those of Edström [15] who found financial strength at the industry level to determine JV activity. Though the current study does not consider financial variables at the industry level, they are considered at the firm level. Some evidence was found suggesting that financial weakness (or aggressiveness), rather than financial strength, might be a determinant of JV formations, accounting for interfirm differences among large firms. Financial weakness is implicit in the negative signs of the current ratio (CR) and the positive sign of the debt to equity ratio (DE) in equations (1) and (3) in Table 5.2. The negative impact of higher rates of return on JV propensities at both the firm and industry level lends credance to this interpretation. Firms with higher debt and lower liquidity engaging in JVs is consistent with financial weakness, although it may imply less risk aversion or even rapid growth strategies.

Other results reinforce previous studies. Within large firms in an industry, JV activity increases with size, confirming Boyle's [11] observations. The cross-industry results on capital growth parallel some of Gort's [21] findings on mergers. Gort also found the

technical personnel ratio in an industry to be positively related to all merger activity. This corresponds to the current finding for technologically oriented JVs. The difference between technological and nontechnological JVs in their R&D intensity relations suggests that a technological, nontechnological split may be useful for merger studies. If the economies of scale variable is interpreted as a proxy for entry barriers, a valuation discrepancy interpretation of JV activity is given some support. Clearly, more work needs to be done in this area.

CHAPTER 6

CROSS FIRM EFFECTS OF JV ACTIVITY: STUDIES OF R&D SUBSITUTION AND RATE OF RETURN IMPACTS

The Chapter 4 discussion on firms' timing decisions for product introduction raised a question about the effect of JV activity on firms' R&D spending. From that analysis, it is hypothesized that R&D substitution occurs because JVs speed up introduction and reduce risks. R&D substitution is the focus of the first part of this chapter. Subsequent to the R&D substitution tests, the impact of JV activity on firms' profitability, measured as rate of return on assets, is examined.

As with the last chapter, the analysis is performed at as disaggregated a level of industry composition as possible. Chow tests are applied to each set of disaggregated results to test for industry similarities in both R&D and rate of return.

6.1 A Model of R&D Determination

To test the direct impact of JV on R&D, a model of R&D determination is employed. If JVs substitute for R&D expenditures as hypothesized, we should observe a decrease in R&D expenditures for those firms that engage in JVs. Two possible JV effects are examined: (1)

the effect of recent JVs, JV3Y, on R&D and (2) the effect of JV activists, JVA, on R&D.[1]

The above two JV measures provide somewhat different tests of JVs impacts. For recent JVs, the tests examine the short run impacts on R&D. A negative impact from recent JVs will indicate that JV competes directly with R&D for funds.

When the JV activist measure is employed, the tests can be interpreted as measuring long run impacts, since the typical JV activist had some JVs which occurred in the earlier years of the JVAP data base. Furthermore, we can reasonably expect that JV activists will view JVs as a viable planning alternative. They then might reduce their R&D budgets from the expectation that they can satisfy future technological needs through external acquisition. Since this effect should be more pronounced for a JV activist than for a firm which uses JV irregularly, the impact on R&D from JVA should be stronger than the JV3Y impact.

Model variables other than JV. The current model does not attempt to present new theory on R&D determination other than that relating to the impact from JVs. Thus, model variables other than JV are taken from previous studies. The variables chosen represent firm size and profitability.

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[1] A firm is designated a JV activist if it engaged in 3 or more JVs in the 1964-1973 period. If a firm engaged in 1 or 2 JVs during the period it is expected that the firm is responding to some non-repetitive external opportunity, whereas 3 or more JVs is expected to indicate a more active role in seeking out JV opportunities.

As a measure of the effect of firm size on R&D, Scherer's [51] recommendation for using a polynomial in sales is adopted, as opposed to the log linear specification proposed by others (see the discussion in Section 2.3). In this study a quadratic specification of sales is adopted. The expected signs are RD/ S 0 and RD/ S^2 0, depending on the industry group involved (RD equals R&D expenditures and S equals sales).

The measure of profitability is cash flow deflated by sales, CF/S. The purpose of deflation is twofold: (1) to represent cash flow as relative profitability and (2) to alleviate the problem of multicollinearity between sales and cash flow.

Cash flow may represent high past productivity in R&D, the success-breeds-success concept proposed by Grabowski [22]. The greater are current profits from past R&D, the greater is the expected benefit of future profits from current R&D and the more the firm is willing to spend (i.e., RD/ CF/S 0).

The CF/S variable can play another role in the equation. With R&D treated as an investment alternative we can assume that firms will expand their R&D spending until the marginal rate of return to R&D, MRR, equals the marginal cost of funds, MCF.[2] Treated in this way, the equation becomes a reduced form equation and cash flow can be interpreted as affecting R&D expenditures from the cost, or sources of funds, side of the equation as well as from the returns side.

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2 This approach has been employed by Grabowski and Baxter [23], Grabowski and Mueller [24], and Howe and McFetridge [28].

This implies that CF/S may also act as a proxy for the cost of capital. The expected sign is again positive.

The model employed is as follows:

$$RD = a_o + a_1S + a_2S^2 + a_3CF/S + a_4JV$$

where RD = R&D expenditures for 1973, S = 1973 sales, CF = 1973 cash flow, and JV is a 0,1 dummy variable. The use of cross section data requires that the estimated regression coefficients be interpreted as long-run elasticities.[3]

The model as specified is a single equation model and is not adjusted for some common statistical problems that may occur. First, it is quite reasonable that the R&D level model is heteroscedastic. To adjust for this problem the model was run with simple deflation by sales.[4] Unfortunately, the heteroscedastic adjusted model degenerated, the explained variation and variables' significance were generally poor. Therefore, the level equations are reported. The reported results are, however, unbiased and consistent.

Secondly, there exists the problem of simultaneity bias. The results in this respect are a bit more promising. The first source of this problem arises from simultaneity between JV and R&D. The model with JV as the dependent variable in the last chapter indicates

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[3] See Kuh [33], p. 182.

[4] Kuh and Meyer [34] point out that simple deflation works well for most economic models. In particular, Scherer [53] points out that simple deflation was adequate for the R&D model he employed, though his dependent variable was R&D employees rather than R&D dollars.

little or no impact from R&D (recall, only the Chemicals group showed a marginal impact). Furthermore, a simultaneous model with both JV and RD specified as endogeneous variables indicated no simultaneous bias,[5] though this result may stem from model specification. Note, however, that these results on simultaneity bias apply to firm differences within an industry. The results from Section 5.4 indicate that, between industries, R&D is a determinant of the level and intensity of technologically oriented JVs. Thus, while causality does not appear to run from R&D to JV at the firm level of analysis, it does appear to cause variations in industry level JV activity.

A second possible source of simultaneity bias stems from the other assumed exogeneous variable, CF/S. For example, Mueller [45] specifies a simultaneous equation model with R&D, investment, dividends, and advertising as codetermined variables. However, the results of R&D equations for both direction and magnitude have not dramatically differed between studies using simultaneous models and studies using single equation models. Howe and McFetridge [28, p. 69], in their study, find "the single equation approach is adequate to the analysis of the determinants of R&D expenditures." A possible rationale for their observation is that the R&D equation may be part of a recursive system, as suggested by Cowling [14]. No simultaneity bias is thus expected in the current results.

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[5] The model tested is one proposed by Madalla [36] when one of the endogenous variables is dichotomous. It essentially recognizes the implied information in an observed decision and uses this information to adjust for "selectivity bias."

6.2 Direct Tests of R&D Substitution: Evidence From Cross-firm Samples

6.2.1 Related Evidence

Before proceeding to the results of the R&D determination model it will be useful to consider some related evidence on R&D substitution. In Friedman, Berg, and Duncan [19], it is shown that most JVs occur in manufacturing and mining industries. Manufacturing and mining industries tend to conduct more R&D than do other industries. Furthermore, among mining and manufacturing industries there is a higher concentration of JVs in the more R&D intensive industries. This higher concentration of JVs in more R&D intensive industries is a necessary condition for R&D substitution. If the converse held, the R&D substitution hypothesis would be much less plausible.

Next, the JVAP conducted a survey questionnaire of joint venturing firms. The response rate was quite small,[6] but the respondents were quite consistent in two respects. Greater than 88% of the respondents stated that the "partner's technological experience and know-how" was important or very important, regardless of industry. The responses to "your firm's technological experience and know-how"

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6 Seventeen firms from SIC's 28,35,36,37, and 38 are included in this analysis.

showed the same response strength as the partner's technological experience, again greater than 88% of the respondents ranked their own technological experience as important or very important. This evidence leads to the expectation that it is technologically oriented firms acquiring external technological inputs.[7]

The remaining items in the questionnaire (representing such items as economies of scale, financial considerations, market penetration, risk, etc.) drew much less consistent responses, indicating the diversity of JV behavior. Table 6.1 presents a summary of the response frequencies. The only other response that exhibits any strength in terms of importance is rapid market penetration. This, however, is also consistent with knowledge acquisition.

6.2.2 The data for the R&D determination model

The data consist of 482 observations taken from Chemicals (SIC 28), Petroleum Refining and Building Materials (SIC 29), Metals (SIC 33), Nonelectrical Machinery (SIC 35), Electrical Machinery (SIC 36), and Transportation (SIC 37). These industries were chosen because they contain the greatest amount of JV activity of all industries under study.

The industries are aggregated into three groups for analytic purposes. Group 1 is the Chemicals industry. It is possible to

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[7] Note, the questionnaire respondents were all large firms, defined as large enough to be included in the Compustat data base. The theoretical arguments of Section 4.3 also lead to the expectation that these firms are recipients of R&D inputs.

Table 6.1

Questionnaire Responses for Motive of JVs

	Very important	Important	Somewhat important	Of little importance	Of no importance	Do not know
1. Patents held by your firm	5	1	1	5	4	0
2. Your firm's technological experience and know-how	10	5	1	1	0	0
3. Patents held by another party	2	2	3	4	4	2
4. Partner's technological experience and know-how	11	4	2	0	0	0
5. Production scale economies	1	3	5	5	3	0
6. Marketing and distribution scale economies	2	4	3	6	2	0
7. Rapid market penetration	2	9	2	3	0	1
8. Joint specification by parents of performance characteristics	3	3	5	3	3	0
9. Financial constraints	3	4	6	3	1	0

analyze this industry separately since there are a sufficient number of JV observations to capture variation in R&D due to the JV effects. Group 2 is composed of the Resource based industries - Petroleums and Metals. Group 3 is composed of Engineering based industries--Non-electrical Machinery, Electrical Machinery, and Transportation. Aggregation for these latter two groups is necessitated by a low number of JV observations in the individual industries.[8]

The data sources are Compustat for nonJV data and the JVAP data base for JVs. The criterion for inclusion of a firm in the data set is complete Compustat data in 1973. Again, since only Compustat firms are involved, the analysis focuses only on large firms.

Table 6.2 presents a summary of the number of firms and JVs in the data set. Subsequent tests use both the measure of current JV activity, JV3Y, and a JV activists measure, JVA. The dummy variable representing current JV activity is defined as JV3Y = 1 if a JV occurred between 1971 and 1973 and JV3Y = 0 otherwise. The dummy variable representing JV activists is defined as JVA = 1 if the firm had 3 or more JVs between 1964 and 1973 and JVA = 0 otherwise.

The three year representation for recent JVs, JV3Y, is chosen based on several considerations. First, if 1973 JVs were the only ones included, the aforementioned problems of small numbers of

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8 Essentially, the fraction of variation that can be accounted for by a variable with few observations cannot be large, particularly when the variable is dichotomous. The problem is similar to insufficient degrees of freedom. Thus, aggregation was necessary to capture the economic effects of JV activity.

observations would become more acute. This is perhaps the most pressing reason. Secondly, the point at which a JV enters the JVAP data set is a mixture of announcement of intention to enter a JV and actual start up dates.[9] This mixture of recognition dates makes it more reasonable to use the 1971 and 1972 entries, since economic impacts from these JVs may not occur until later when operating funds are allocated to the JV. Finally, it is reasonable to suppose a lag effect running from JV to R&D. Firms may wait until some degree of success is achieved to alter their R&D budgets.

Columns (4) and (5) of Table 6.2 indicate the overlap between JVA and JV3Y. The only industry that shows extreme overlap is Chemicals (SIC 28), where all 10 JV activist firms also had JVs in 1971-1973. The short run interpretation for the SIC 28 equation using JV3Y is therefore tenuous.

Before proceeding to the multivariate analysis one further observation is useful. A desirable characteristic of JVs in the data set is that the majority should be technologically oriented. Table 6.3 presents a percentage breakdown of the stated purpose of the JV by industry. For Chemicals and Engineering groups, technologically oriented JVs predominate.[10] In the Resources group there is a slightly

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9 The possibility also exists that some JVs were not picked up until after the JV had begun operations.

10 Technologically oriented JVs are taken as those with an expressed purpose of R&D, production, or some combination including R&D or production.

Table 6.2

Data Set Characteristics for R&D Determination Equations

Industry	SIC	N[a] (1)	JV3Y[b] (2)	JVA[c] (3)	Overlap Between JV3Y and JVA (4)	% overlap[d] (5)
Chemicals	28	97	12	10	10	83%
Petroleums and Building Materials	29	28	10	14	8	57
Metals	33	47	8	5	4	50
Nonelectrical Machinery	35	121	13	5	5	38
Electrical Machinery	36	104	7	3	2	28
Transportation	37	85	12	4	3	40
Totals		482	62	41	32	

a N = number of firms.
b JV3Y = JV occurrences between 1971 and 1973.
c JVA = 3 or more JVs between 1964 and 1973.
d The percentage represents the lower of (4)/(2) or (4)/(3).

Source: Compustat and JVAP Data Base.

Table 6.3

Percentage Distribution of JV Characteristics by Industry:
Compustat Sample (1971-1973)

Industry	SIC	(1) Technology/ Knowledge	(2) Resource/ Construction	(3) Marketing
Chemicals	28	69.5	21.8	8.7
Petroleums & Building Materials	29	44.4	51.8	3.8
Metals	33	47.4	47.4	5.2
Nonelectrical Machinery	35	88.9	0	11.1
Electrical Machinery	36	80.0	10.0	10.0
Transportation Equipment	37	93.3	6.7	0

Source: JVAP Data Base.

stronger orientation towards resource acquisition and construction JVs. This evidence leads to the expectation that R&D substitution should be stronger for Chemicals and Engineering industries.

6.2.3 Evidence on R&D Substitution: Recent JV Activity (JV3Y)

Table 6.4 presents the results of the R&D determination model using JV3Y. The results are presented for the three industry groups --Chemicals, Resources, and Engineering--as well as the results for groups combined.

In all cases sales, S, is positive, significant as hypothesized. Thus, as firms increase in size they tend to spend more on R&D. The proportionality between sales and R&D is maintained for the Engineering group only, with sales increasing nonlinearly in a positive way for Chemicals[11] and increasing nonlinearly in a negative way for Resources.

The CF/S variable is positive, significant for Chemicals and Engineering. Thus, larger relative cash flow results in greater R&D expenditures for these groups, as hypothesized. In the Resources group the sign of CF/S is negative, but insignificant. This is probably due to the resource acquisition and fabrication nature of these industries. Cash flow in these groups is more likely to be channeled into capital goods purchases for extraction or production

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11 The Chemicals result is consistent with the previous findings of Mansfield [38].

Table 6.4

Results for the Impact of Recent JVs on R&D: R&D Determination Equations

Equation	SIC(S)	C	S	S^2	CF/S	JV3Y	R^2	F	SSE
(1)	28	-8.60	.020	3.8×10^{-6}	135.27	-13.82	.82	105.45	23891.021
		(-2.35)	(4.08)	(3.30)	(4.30)	(-2.45)			
(2)	29,33	-1.14	.009	-3.2×10^{-7}	-10.70	1.48	.78	64.29	4326.253
		(-.56)	(7.00)	(-2.31)	(-.48)	(.63)			
(3)	35,36,37	-20.11	.035	1.0×10^{-9}	266.05	-13.16	.93	1069.67	203178.068
		(-6.44)	(23.16)	(.03)	(6.70)	(-2.54)			
(4)	28,35,36,37	-16.22	.035	1.0×10^{-9}	197.22	-16.04	.92	1262.65	234958.453
		(-6.72)	(27.03)	(.01)	(7.11)	(-3.88)			
(5)	28,29,33	-7.82	.023	-1.6×10^{-6}	92.41	-10.89	.46	35.71	86786.063
		(-2.10)	(8.19)	(-5.15)	(2.54)	(-2.13)			
(6)	28,29,33,35 36,37	-7.42	.022	3.7×10^{-7}	106.94	-11.51	.85	680.44	479781.872
		(-2.55)	(15.55)	(7.30)	(3.21)	(-2.47)			

Note: Values in parentheses are t statistics.

Table 6.5

Chow Tests for Homogeneity of Industry Groups

SIC'S Combined[a]	Degrees of Freedom	F[b]	Significance
28;35,36,37	5,397	2.75	--
28;29,33	5,162	67.25	.01
28,35,36,37;29,33	5,472	94.87	.01

[a] The semicolon delimits the groups combined.

[b] The combination between SIC 28 and SIC's 35, 36, and 37 can be rejected at the 5% level of significance, $F_{.05}$ with 5,400 degrees of freedom is 2.23, but cannot be rejected at the 1% level, $F_{.01}$ with 5,400 degrees of freedom is 3.06. The other combinations can be rejected at any relevant level of significance.

rather than increased R&D expenditures since the former activities are more central to the firms' operations.[12]

The results for JV3Y confirm previous suspicions. The Resource group shows a positive, but insignificant effect on R&D. We can therefore reject R&D substitution for this group. The reason is the same as discussed for the CF/S variable, the lesser reliance on R&D to generate future income. The Chemicals and Resources groups both show a negative, significant effect on R&D. For these groups we can accept the hypothesis of R&D substitution. Furthermore, the size of impact appears to be similar between the two groups, with $a_4 = -13.82$ for Chemicals and $a_4 = -13.16$ for Engineering. These results are interpreted as short run impacts since JV3Y measures recent JVs. Thus, JV appears to compete directly with R&D for funds, with fairly rapid effects on R&D budgets.

Table 6.5 presents Chow tests for homogeneity between the industry groups. The results indicate that R&D determination differs from group to group. Chemicals and Engineering do exhibit some homogeneity, but the relation is weak; we can reject homogeneity at the 5% level but not at the 1% level of significance.[13] The

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12 The Resource industries tend to exhibit the lowest R&D intensity of all industries under consideration. Lower R&D intensity tends to indicate lesser importance of this type of activity to these firms.

13 In Friedman, Berg, and Duncan [19] the Chemicals included only Basic Chemicals, SIC 281, and Drugs, SIC 283. When the other chemical SICs are omitted homogeneity obtains between Chemicals and Engineering. Thus, the weakness of homogeneity can probably be attributed to the inclusion of the other three digit SICs in Chemicals.

relation between Chemicals and Resources is clearly heterogeneous and the relation between Chemicals and Engineering combined and Resources is heterogeneous. The results with industries combined all yield negative, significant results for JV3Y. The negative effect from Chemicals and Engineering appears to dominate the effect from Resources.

6.2.4 Evidence on R&D Substitution: JV Activists (JVA)

Table 6.6 presents the results of R&D determination using JVA, again employing the three industry groups and groups combined. All variables retain the same sign as observed in the JV3Y results. The performance of S^2 in the Resources group improves somewhat; S^2 for this group is significant at the 10% level. The significance of JVA for Resources also improves but still remains insignificant, even at the 10% level. The Chow tests, Table 6.7, produce the same results as before.

Section 6.2.2 results indicate the short run impact of JV. These JVA results, however, are interpreted as indicating the long run impact of JV on resources devoted to R&D. The primary observable difference between the two sets of results is the magnitude of the JV coefficients. It appears that the measure of JV activists has a stronger impact than does the measure of recent JV activity. In Chemicals, $a_4 = -15.93$ for JV activists as opposed to $a_4 = -13.82$ for recent JV activity; in Engineering, $a_4 = -22.66$ for JVA as opposed to $a_4 = -13.16$ for JV3Y.

Table 6.6

Results for the Impact of JV Activists on R&D: R&D Determination Equations

Equation	SIC(S)	C	S	S^2	CF/S	JVA	R^2	F	SSE
(1)	28	-8.18 (-2.27)	.018 (3.99)	4.1×10^{-6} (3.74)	138.19 (4.42)	-15.93 (-2.82)	.82	108.06	23415.956
(2)	29,33	-.566 (-.28)	.009 (5.76)	-2.6×10^{-7} (-1.69)	-16.28 (-.71)	3.18 (1.08)	.78	65.20	4278.714
(3)	35,36,37	-21.64 (-7.09)	.034 (23.68)	1.0×10^{-9} (.06)	282.54 (7.19)	-22.66 (-2.85)	.93	1075.81	202095.091
(4)	28,35,36,37	-17.73 (-7.41)	.034 (27.57)	1.0×10^{-8} (.23)	213.37 (7.68)	-22.62 (-4.07)	.92	1267.69	234094.177
(5)	28,29,33	-9.94 (-2.76)	.027 (9.48)	-1.9×10^{-6} (-6.20)	112.05 (3.19)	-24.09 (-4.15)	.50	42.86	79451.725
(6)	28,29,33,35 36,37	-9.68 (-3.41)	.023 (16.96)	3.3×10^{-7} (6.49)	139.05 (4.21)	-30.37 (-5.40)	.85	718.66	457897.3

Note: Values in parentheses are t statistics.

Table 6.7

Chow Tests for Homogeneity of Industry Groups

SIC'S Combined[a]	Degrees of Freedom	F^b	Significance
28;35,36,37	5,397	3.02	--
28;29,33	5,162	60.55	.01
28,35,36,37;29,33	5,472	86.93	.01

[a] The semicolon delimits the groups combined.

[b] The combination between SIC 28 and SIC's 35, 36, and 37 can be rejected at the 5% level of significance, $F_{.05}$ with 5,400 degrees of freedom is 2.23, but cannot be rejected at the 1% level, $F_{.01}$ with 5,400 degrees of freedom is 3.06. The other combinations can be rejected at any relevant level of significance.

The increased impact due to JVA over JV3Y is stronger for Engineering. This, however, is not surprising since JV3Y and JVA show an 83% overlap in Chemicals.[14] Since 10 Chemical firms in JV3Y overlap the 12 in JVA it is difficult to interpret the JV3Y effect as short run. The overlap suggests that the 10 firms are also subject to the long run influences of past successes. However, the omission of the 2 JVs that were not also JVAs does cause the negative impact to become stronger and is consistent with a stronger effect from JV activists. This effect is much clearer in the Engineering group.

If, however, JV activist firms are larger than firms engaging in JVs between 1971 and 1973, the result on stronger long run impacts may be mitigated. We would expect, for example, the coefficients on JVA to be greater than that on JV3Y if JV activity affects internal R&D activity proportionately.

6.2.5 A Result on the Importance of Industry Effects on R&D Determination

There is one other result, not presented in the tables, that merits comment. Other authors, among them Scherer [52] and Mueller [44], have noted a strong industrial element in explaining differences in R&D behavior. Scherer, for example, introduces industry dummies and finds that they explain much of the variation in R&D behavior. In an attempt to capture this effect, industry dummies were introduced into equation (6) in Table 6.4. None of the

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[14] See Table 6.2.

industry dummies, however, were significant. Thus, the introduction of externally acquired knowledge into the R&D determination model provides an alternative explanation to the industry effect observed in previous studies. This suggests the importance of externally acquired knowledge as one of the defining characteristics of inter-industry differences (a subject dealt with more fully in the next chapter).

6.3 Rate of Return Determination: Indirect Tests of Knowledge Acquisition Activities Via JV

Let us suppose for the moment that firms use JVs to augment market power. Some possible means by which this can occur are that firms use JVs to fix price, limit supplies, or employ one of a number of other forms of collusive behavior. If this type of behavior is prevalent among joint venturing firms, we should observe increased rates of return (RR) for firms that use JVs relative to non-joint venturing firms. Furthermore, the issue of market power augmentation through collusion has been central to many studies of JVs;[15] thus, it is important to consider this possibility.

Increased rates of return are not the only reason firms collude, nor is it the only effect that may occur. Risk reduction may be the motivating force behind and principal effect of collusion. For

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[15] See Section 2.2 for a discussion of studies with market power as a central hypothesis.

example, in division of market, the risks associated with competition and loss of market share are circumvented. However, for any broad based sample we should be able to detect market power augmentation in increased RR, though this need not be reflected in an individual firm's activity. Nor is market power augmentation the only explanation for increased RR to JV firms. Efficiency gains or superior bargaining ability can also produce increased RR. The observance of higher RR for JV firms is, however, consistent with market power augmentation and collusion and would therefore raise serious suspicions as to its possibility.

Alternatively, JVs may exert a negative influence on RR.[16] Such a result would be consistent with risk reduction activities or acquisition of external knowledge[17] (for example, acquisition of R&D knowledge, as was tested in Section 6.2, or acquisition of marketing knowledge, as in a new market entry JV).

For these activities, JVs can be expected to exert a negative influence on RR since risk premiums would be paid for risk reduction or economic rents would be demanded by knowledge suppliers.[18]

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16 The following arguments follow much the same line of reasoning as proposed and tested in Berg and Friedman [6].

17 Note that these tests represent an indirect test of knowledge acquisition, as opposed to the direct tests of R&D substitution in Section 6.2. These tests are more general than the R&D substitution tests since any form of knowledge acquisition is encompassed. It is expected, however, that the primary effect captured in the RR tests stems from R&D substitution.

18 Again, the assumption is made that the firms in the sample are recipients of knowledge inputs, as discussed in Chapter 4.

6.3.1 The Model

The model used here is:

RR_i = f (Lagged R&D intensity; Size; JVs).

This model is similar to one employed in Berg and Friedman [6] except for the exclusion of diversification and the form of the lag in R&D.[19] In further contrast to Berg and Friedman, tests will be extended to include the Resources and Engineering groups tested in Section 6.2.

Diversification is omitted from the model for several reasons. First, the data set is not as complete for this variable in non-Chemicals industries and the number of usable observations would have been reduced. Second, it is not clear that the number of product lines (Berg and Friedman's measure) is a good measure of the effects of diversification. It is possible, for example, for two firms to have the same number of product lines, but for one of the firms to depend almost exclusively on a single line for its revenues while the other's revenue sources are more dispersed throughout several product lines. In the former case, the impact of additional product lines can be quite small, whereas for the latter the impact may be substantial. Third, the impact of diversification in the Berg and Friedman model was small relative to the other variables.

The lagged R&D intensity (RD/S) variable is represented by an equally weighted lag structure over $(RD/S)_t$, $(RD/S)_{t-1}$, and $(RD/S)_{t-2}$,

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19 Berg and Friedman's model was:
RR_i = f (Lagged R&D intensity; Size; Diversification; JVs).

where t=1973. Branch [12], Grabowski and Mueller [24], and Howe and McFetridge [28], among others have identified the R&D intensity of a firm as a determinant of profitability. Past R&D may be expected to impact on current profitability. The expected sign is $\partial RR/\partial RD/S > 0$.

In Berg and Friedman, lagged R&D intensity was represented by a quadratic polynomial distributed lag with the weights: $w_t = .299$, $w_{t-1} = .399$, and $w_{t-2} = .302$. The polynomial was estimated using the average R&D intensity of Chemical firms over a 10 year period. While Chemical firms' R&D data is complete enough in earlier years to allow the lag estimation, for the other industries under consideration R&D data is much less complete. Since an estimated lag structure was not obtainable, two possible structures were tested. The first used only contemporaneous RD/S; the second used an equal weighting scheme. The equal weights produced overall better results and are the ones reported.

The next model variable, firm size, is measured by log sales, Log S. Size variables can be used to capture the effects of barriers to entry and economies of scale. Hall and Weiss [25] have found evidence of a positive effect from size, which they explain in terms of significant capital requirements barriers. Either argument, barriers to entry or scale economies, produces a positive expected sign ($\partial RR/ \partial \text{Log } S > 0$).

Joint venturing is represented by recent JVs, JV3Y, and by JV activists, JVA, both entering as dummy variables. The Section 6.1

discussion applies - JV3Y will be interpreted as the short run effect and JVA as the long run effect when JV is used as a planning strategy. Following from the knowledge acquisition hypothesis the expected signs are negative. A positive sign will be interpreted as evidence consistent with possible market power augmentation.

The estimated model implied from the previous discussion is:

$$RR_i = b_o + b_1\,[w_1(RD/S)_{t,i} + w_2(RD/S)_{t-1,i} + w_3(RD/S)_{t-2,i}]$$
$$+ b_2(\text{Log } S)_i + b_3 JV3Y_i + e_i.$$

In Section 6.2.3 the impact of JV on R&D increased when JVA was employed as the JV measure, relative to JV3Y. The JVA effect on RR, however, is expected to diminish relative to JV3Y's effect, given support for knowledge acquisition. The cost of acquiring knowledge should occur primarily at the start of the project and diminish over the life of the project.

The opposite is expected if market power augmentation is indicated. The effects of collusion are expected to increase over time as firms work together; and, in fact, collusion may not be revealed at all using recent JVs since increased profitability may hinge on the JV being fully operational. This, however, is compensated for by using the 3 year measure for recent activity. The 3 year measure creates some bais toward capturing market power effects.

6.3.2 The Data

The sample consists of 345 observations taken from the Chemicals (SIC 28), Resources (SIC's 29 and 33), and Engineering (SIC's 35, 36,

and 37) groups. The data are the same as those used in the R&D substitution tests except observations are omitted when sufficient lagged R&D data is missing. Missing lagged R&D data causes the loss of 137 observations. Table 6.8 presents a summary of the number of observations per industry, the number of recent JVs, JV3Y, the number of JV activists, JVA, and the overlap between JV3Y and JVA for the 345 sample. As with the sample for the R&D model, SIC 28 shows a significant degree of overlap between JV3Y and JVA.

6.3.3 Evidence from the RR Determination Model: Recent JV Activity (JV3Y)

Table 6.9 presents the results of the RR determination model using JV3Y. The results are presented for the three industry groups --Chemicals, Resources, and Engineering--as well as the results from the groups combined.

The results confirm the Berg and Friedman results for the Chemicals industry. JV3Y is negative, significant as they obtained and is thus consistent with the knowledge acquisition hypothesis, and not the market power hypothesis.

The omission of diversification does alter the results somewhat. The proportion of explained variation, R^2, is higher with diversification omitted and both lagged RD/S, WRD, and JV3Y are more significant. The Berg and Friedman equation is:[20]

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20 Berg and Friedman [6], p. 1335.

Table 6.8

Data Set Characteristics for RR Determination Equations

Industry	SIC	N[a] (1)	JV3Y[b] (2)	JVA[c] (3)	Overlap Between JV3Y and JVA (4)	% overlap[d] (5)
Chemicals	28	80	11	9	9	82%
Petroleums and Building Materials	29	18	8	12	6	50
Metals	33	34	7	5	4	57
Nonelectrical Machinery	35	90	11	5	5	45
Electrical Machinery	36	73	6	2	1	17
Transportation	37	50	10	3	2	20
Totals		345	53	36	27	

[a] N = number of firms.
[b] JV3Y = JV occurrences between 1971 and 1973.
[c] JVA = 3 or more JVs between 1964 and 1973.
[d] The percentage represents the lower of (4)/(2) or (4)/(3).

Table 6.9

Results for the Impact of Recent JVs on Rates of Return: RR Determination Equations

Equation	SIC(S)	C	WRD[a]	LogS	JV3Y	R^2	F	SSE
(1)	28	.037	1.017	.025	−.037	.29	10.59	.17276
		(1.57)	(3.96)	(2.57)	(−2.19)			
(2)	29,33	.097	.075	.001	−.006	.006	.11	.05335
		(5.38)	(.13)	(.22)	(−.58)			
(3)	35,36,37	.067	.268	.014	−.022	.05	4.41	.54676
		(5.57)	(1.64)	(3.02)	(−1.99)			
(4)	28,35,36,37	.055	.510	.019	−.027	.12	13.25	.75091
		(5.15)	(3.67)	(4.51)	(−2.97)			
(5)	28,29,33	.063	1.04	.013	−0.22	.26	15.29	.23706
		(4.06)	(5.74)	(2.18)	(−2.19)			
(6)	28,29,33,35,36,37	.060	.530	.016	−.024	.11	14.05	.81303
		(6.37)	(4.28)	(4.37)	(−3.10)			

[a] $WRD = 1/3\ (RD/S)_t + 1/3\ (RD/S)_{t-1} + 1/3\ (RD/S)_{t-2}$.

<u>Note</u>: Values in parentheses are t statistics.

RR_i = .039 + .49 WRD + .038 Log S - .027 JV3Y - .0035 DIV,

(1.71) (1.93) (3.61) (-1.35) (-2.65)

R^2 = .18, N = 105.

There are, however, other differences than the diversification variable that may explain the altered results: the sample size is different and the lag structure for RD/S is different. It may be these other factors or some combination of factors, rather than strictly the omission of diversification, that explain the difference between their equation and the Chemicals' equation in Table 6.9.

Equation 3 in Table 6.9 illustrates the Berg and Friedman results are more general, in that they apply to a broader group of industries. JV3Y is again negative, significant supporting knowledge acquisition and rejecting market power augmentation. Both WRD and Log S perform as expected for Chemicals and Engineering; both are positive, significant.

The results for the Resources group are quite different, neither WRD or Log S are significant. In fact, the equation performance is quite poor overall, since R^2 is only .006 and the F test for explanatory power of the entire equation is insignificant at any relevant level of significance. The JV3Y results, however, do not indicate market power augmentation, which is perhaps the only positive result from equation (2). On the other hand, we cannot accept the knowledge acquisition hypothesis either. In general, it appears that more work is needed in specifying a model for this group. The inclusion of variables that reflect the resource acquisition and

fabrication nature of these industries and perhaps some variables reflecting international trade arrangements[21] would probably yield an improved model specification and improved results. Unfortunately, the current data base does not include the needed variables.[22]

Table 6.10 presents the Chow tests for industry combinations. These results indicate that homogeneity in rate of return determination can be accepted for the Chemicals, Resources combination. This result seems unusual in light of the previous disaggregated results. A possible explanation is that Chemicals' results dominate the Resources' results. In the first place, Chemicals has 80 observations, as opposed to 52 for Resources; and second, the combined results tend to approximate Chemicals results more closely than those of the Resources group. Regardless of the explanation, the combined Chemicals and Resources results are consistent with knowledge acquisition and reject the market power hypothesis.

When Chemicals are combined with Engineering we cannot accept homogeneity at the 5% level of significance, but we cannot reject it at the 1% level. The same result obtains when Chemicals and

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21 For example, the profitability of the large integrated oil firms can be expected to be sensitive to international developments, such as the OPEC cartel; and the major steel firms, another part of this sample, can be expected to be sensitive to international developments in steel production.

22 In particular, variables that reflect exploration and drilling, or possibly the firm's exploration budget, for Petroleum firms and mining activities for Metals firms should dramatically improve the model performance. Also, the inclusion of capital spending and an alternative size specification might improve the results.

Table 6.10

Chow Tests for Homogeneity of Industry Groups:
RR Equations Using JV3Y

SIC'S Combined[a]	Degrees of Freedom	F
28;35,36,37	4,285	3.11[b]
28;29,33	4.124	1.50[c]
28,29,33;35,36,37	4,337	3.13[b]

[a] The semicolon delimits the groups combined.

[b] Reject homogeneity at the 5% level of significance, but we cannot reject at the 1% level.

[c] Accept homogeneity.

Resources taken together are combined with Engineering. At best, the evidence is weak that these respective groups are homogeneous with respect to RR determination, indicating the separate results are probably superior.

The combined results do support the hypothesis of knowledge acquisition via JVs. Further, these results are complementary in all respects to those obtained in Section 6.2. The robustness of JV3Y is reassuring in terms of the general theory of knowledge acquisition for JVs in manufacturing and mining industries. The one principal exception appears to occur in Resource related industries where JVs may be more closely related to the acquistion of oil and minerals, rather than knowledge. The negative sign of JV3Y in equation (2) is consistent with risk averse behavior in risky resource acquisition.

6.3.4 Evidence from the RR Determination Model: JV Activists (JVA)

Table 6.11 presents the RR determination results for the three industry groups using JV activists, JVA, as the measure of JV activity. The variables WRD and Log S are not appreciably altered by using JVA in place of JV3Y. The discussion of the previous two sections therefore apply and attention will be restricted to the JV variable.

Section 6.3.1 suggested that we could expect the JVA impact on RR to diminish relative to that of JV3Y, given the knowledge acquistion hypothesis. This is precisely what occurs for Chemicals

Table 6.11

Results for the Impact of JV Activists on Rates of Return: RR Determination Equations

Equation	SIC(S)		WRD[a]	LogS	JVA	R^2	F	SSE
(1)	28	.044	1.033	.021	-.027	.27	9.41	.17862
		(1.87)	(3.93)	(2.20)	(-1.47)			
(2)	29,33	.089	.009	.005	-.015	.03	.49	.05211
		(4.71)	(.02)	(.73)	(-1.21)			
(3)	35,36,37	.069	.293	.013	-.019	.04	3.47	.55379
		(5.66)	(1.77)	(2.70)	(-1.12)			
(4)	28,35,36,37	.057	.535	.017	-.023	.10	11.27	.76473
		(5.32)	(3.83)	(4.07)	(-1.85)			
(5)	28,29,33	.061	1.00	.014	-.023	.26	15.20	.23743
		(3.83)	(5.34)	(2.28)	(-2.15)			
(6)	28,29,33,35,36,37	.061	.529	.015	-.023	.10	12.89	.82050
		(6.31)	(4.24)	(4.17)	(-2.53)			

[a] $WRD = 1/3\ (RD/D)_t + 1/3\ (RD/S)_{t-1} + 1/3\ (RD/S)_{t-2}$.

Note: Values in parentheses are t statistics.

Table 6.12

Chow Tests for Homogeneity of Industry Groups:
RR Equations Using JVA

SIC'S Combined[a]	Degrees of Freedom	F
28;35,36,37	4,285	3.14[b]
28;29,33	4.124	0.89[c]
28,29,33;35,36,37	4,337	3.11[b]

[a] The semicolon delimits the groups combined.

[b] Reject homogeneity at the 5% level of significance, but we cannot reject at the 1% level.

[c] Accept homogeneity.

and Engineering groups. Both the size of the JVA coefficient and its significance decrease. For Chemicals, $b_3 = -.027$ in the RR equation using JVA and is significant at the .1 level, whereas $b_3 = -.037$ in the RR equation using JV3Y and is significant at the .025 level. For Engineering, $b_3 = -.019$ in the equation using JVA and is significant only at the .2 level, whereas $b_3 = -.022$ in the equation using JV3Y and is significant at the .025 level. Therefore, we can infer that firms which JV must relinquish some immediate profitability, but that these losses relative to internal development do not last over the long run.[23]

The results for the Resources group are different from those obtained in Chemicals and Engineering when JVA is used instead of JV3Y. These industries do not conform to the knowledge acquisition hypothesis; they more likely fit a resource acquisition hypothesis. The long run effect for this group appears to be larger (i.e., $b_3 = -.015$ using JVA versus $b_3 = -.006$ using JV3Y). Further, the coefficient of JVA is significant at the .1 level while that of JV3Y is insignificant at any relevant level. The effect is still not strong using JVA, however.

Table 6.12 presents the homogeneity tests for the groups combined. The results are essentially the same as obtained in Section 6.3.3 and, therefore, the same discussion applies.

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23 Recall Table 6.8. There is a much greater overlap between JV3Y and JVA in Chemicals than for the Engineering group. The loss of significance is also much less for Chemicals. It is expected, therefore, that the Engineering results are somewhat more representative of the long run impact on profitability.

CHAPTER 7

CROSS INDUSTRY STUDIES: RATE OF RETURN IMPACTS

The last chapter examined cross-firm impacts from JV activity on firms' R&D spending and rate of return. The next two chapters change the focus to cross-industry impacts from JV activity, while keeping the examination in terms of R&D and rate of return. This chapter first deals with some issues in measuring JV incidence and then examines the rate of return impacts; the next chapter treats R&D impacts.

By changing the focus to the industry level some flexibility is gained in the measurement of JV activity. JV observations are dichotomous at the firm level; however, at the industry level, the dichotomous observations can be aggregated to incidence measures, allowing the examination of differential impacts from the JV classifications discussed in Chapter 3. Those classifications are: the technological- nontechnological purpose of the JV, parent-parent horizontality, and parent-child horizontality. Since Berg and Friedman [10] employed the technological-nontechnological classification in their study of cross-industry rate of return impacts, the analysis here does not include that classification; all three classifications are, however, employed in the next chapter's study of R&D impacts.

The cross-industry analysis addresses different issues than the cross-firm analysis. Whereas the cross-firm analysis addressed the issue of differences between firms within an industry, the cross-industry analysis addresses issues of differences between aggregated groups of firms. Thus, the cross-industry analysis not only reflects the impact on firms which form JVs, but also the impact on firms which do not form JVs. For example, R&D substitution was hypothesized and supported at the firm level, but R&D complementarity is hypothesized at the industry level. Given evidence on R&D substitution at the firm level, the only way R&D complementarity can occur at the industry level is through the effect that JVs exert on nonJV firms.

Through cross-industry analysis, furthermore, a better treatment of market structure impacts on JV activity can be accomplished than through cross-firm analysis. It is not possible, for example, to include market structure measures such as industry concentration at the firm level, since all firms in an industry face the same industry concentration; effects from industry concentration can, however, be examined in the cross-industry analysis. The cross-industry analysis also includes a broader set of industries than did the cross-firm analysis. It is possible, therefore, to include industries with relatively low JV incidence and to compare the market structure characteristics of low and high JV incidence industries.

7.1 Issues in the Construction of JV Incidence Measures

All of the subsequent cross-industry statistical tests use JV incidence or intensity meausures, with observations for each year and

industry. Ideal measures would be based on JVs for the period of time they were in existence. The data set, however, does not contain termination dates, so indexes incorporating beginning and ending dates are not possible. What remains is to employ beginning dates only or to make some assumption about the duration of JVs.

The decision about the appropriate duration over which to measure JV activity depends on the issue involved. The beginning dates are perhaps the best if one is interested in the causes of JV activity, since varying financial and economic conditions through time may alter firms' propensities to form JVs. Thus, the beginning dates were used in the Chapter 5 evaluation of the causes of JV activity.

An alternative to using beginning dates is to assume no termination dates. This is tantamount to assuming all JVs are successful. No serious complication arises from this assumption unless large numbers of JVs are not successful or are formed for only temporary purposes. The terminations, furthermore, must occur in the 1964-1975 period to materially affect the cross-industry analysis.

The assumption of no termination dates suggests the use of cumulative indexes of JV activity. When one is interested in the impact of JV activity on performance measures, such as rate of return, the cumulative indexes are more appropriate, since industrial market structure and performance will be determined more by on-going JVs than by new ones. A new JV, for example, will take time to set up and achieve its full operational impact on the industry.

Furthermore, the effects from collusion are more likely to become visible as firms work together over time. Since part of the cross-industry rate of return analysis is concerned with market power augmentation via JV, as a potential indication of collusive behavior, that analysis uses the cumulative indexes. Also, the current results using the parent-parent horizontality and parent-child horizontality indexes are more comparable to Berg and Friedman's [10] results if the cumulative indexes are used, since Berg and Friedman used cumulative indexes.

One other situation remains. For the case wherein interest is the impact of JVs on a variable they compete with for funds, such as R&D spending or capital investment, the issue of appropriate index is less clear. If, for example, capital rationing exists or additional funds are expensive the decision to enter a JV may have an immediate impact on resources allocated to these other activities. These situations would suggest employing indexes based on beginning dates as more appropriate. On the other hand, past successes in JV formations may induce firms to reduce current expenditures in areas where they can substitute JVs. Past successes may also have an impact on nonJV firms through their effect on the competitive structure of the industry. These arguments suggest the cumulative indexes as more appropriate. Since no a priori reason indicates the superiority of one index construction over the other, both are employed in the next chapter's evaluation of JVs' impact on R&D.

7.2 Statistical Procedure: Cross-pooling Technique

When small sample problems arise in a cross-sectional model, pooling of time-series and cross-section observations can be used to circumvent the small number of degrees of freedom and restrictions on the number of explanatory variables. In the present industrial model, there are from 15 to 19 cross-section observations, depending on the JV indexes chosen.[1] In the broadest specification, there are 15 variables, which would leave no degrees of freedom when parent-parent horizontality indexes are used. Without cross-pooling, some hypotheses on differential industry impacts could not be tested. By cross-pooling the number of observations increases to 165 when 15 industries are used and 209 when 19 industries are used, alleviating the degrees of freedom problem.[2]

When cross-pooling is used, statistical problems that may exist in cross-sectional analysis (heteroscedasticity) and in time-series analysis (autocorrelation) may still remain. The models to be estimated are adjusted for these problems. The analysis follows the following general framework, in matrix form:[3]

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1 When the technological-nontechnological indexes are used there are 19 cross-sectional observations. When the parent-parent horizontality indexes are used, four industries have zero vectors for JV3, parent-parent horizontal, leaving 15 cross-section observations. The zero vectors make it impossible to estimate the time-series autocorrelation coefficients.

2 There are 11 years, 1965-1975, times the number of industries.

3 The econometric sections of this discussion draw heavily on Balestra and Nerlove [5], Kmenta [32], and Pindyck and Rubinfeld [48].

$Y_{i,t} = \beta X_{i,t} + \varepsilon_{i,t}$; $i=1,\ldots,I$; $t=1,\ldots,T$, using the error term assumptions:

$E\,(\varepsilon^2_{i,t}) = \sigma_i{}^2$ (heteroscedastic),

$E\,(\varepsilon_{i,t}\,\varepsilon_{j,t}) = 0$, $i \neq j$ (cross-sectionally independent),

$\varepsilon_{i,t} = \rho\varepsilon_{i,t-1} + \mu_{i,t}$ (autoregressive).

This model can be estimated using a two-part transformation.

1) time series autocorrelation adjustment, and

2) pooled model adjustment for heteroscedasticity.

The autocorrelation adjustments are handled via the Hildreth-Lu grid procedure. The Cochran-Orcutt iterative procedure is used as a check against the Hildreth-Lu procedure. Hildreth-Lu is preferable for the present models since the Cochran-Orcutt procedure sometimes produced rho values above one. This most likely occurs because there are only 11 time-series observations. Cochran-Orcutt also has the potential for sticking at a local maximum rho value when the autoregressive structure is not monotonic, a result that may be produced from the small number of observations.

The heteroscedasticity problem is handled by estimating the models in ratio form. Kuh and Meyer [34] have pointed out that "in most cases of size deflation with cross-section data, although not all, the economic relationships will come close to satisfying the homogeneity requirement," and that deflated results are, at worst, superior to OLS. They further point out that the appropriate size deflator should be as closely related as possible to the variable in question. Thus, for example, R&D dollars is deflated by sales, and capital investment is deflated by total assets.

7.3 Model of Rate of Return Determination

As discussed in Chapter 3, JVs involving parent-parent and parent-child horizontality pose potential anticompetitive problems. Following this line of reasoning, the hypothesis that horizontal JVs are potentially collusive is tested by examining the impact on average industrial rates of return from parent-parent and parent-child horizontal JVs. A positive impact on rates of return (RR) from horizontal JVs (JV3 for parent-parent horizontal and JV5 for parent-child horizontal) will be interpreted as indicating that these JVs are potentially collusive, though other activities which increase rates of return, such as improved operating efficiency, are also possible explanations (i.e., RR/ JV3 0 and RR/ JV5 0).

The hypothesis that a heavy incidence of nonhorizontal JVs (JV4 for parent-parent nonhorizontal and JV6 for parent-child nonhorizontal) lowers industry average rates of return is also tested (i.e., RR/ JV4 0 and RR/ JV6 0). Support for this hypothesis can be interpreted in two possible ways. First, JVs are used for knowledge acquisition purposes, such that they reduce risk, reduce time-lags, or serve other functional purposes. Second, JVs are used for new market entry. New market entry, however, is consistent with knowledge acquisition and is expected to reflect such activity.

To test these hypotheses, a restricted model of rate of return determination is employed. Small degrees of freedom in each

industry's time-series preclude a full model specification; however, it is still possible to focus on the variables of greatest interest.

The variables in the model are industry averages since the focus is differences in industry behavior. Data problems arise in constructing the industry averages. They stem from data limitations and appropriate weighting schemes. The potential weightings are assets, sales, and number of firms. The problems that arise and the weighting schemes will be discussed in the context of each variable used in the model.

7.3.1 Model Variables

The dependent variable is rate of return (RR), measured as net income/assets. It is a weighted average of firm assets in each industry. The weighted average rate of return is calculated as ΣNet Income/Σ Assets. The greatest potential problem in this measure stems from the accounting definition of assets. Errors in dependent variables do not, however, create severe problems; they can be accounted for in the model error term.

The independent variables in the model, other than JV, are log sales, capital growth, and R&D intensity:

1) Log sales (log S) is used to capture demand growth, scale economies, and possibly capital-requirement entry barriers. Demand growth is captured by sales across time, within each industry. Since the cross-pooling technique contains time-series data, it is not necessary to measure demand growth as change in sales, as is done in most cross-section work.

Further, entering change in sales directly would not take into account the cross-sectional component of sales. Log sales is expected to exert a strong positive influence on intertemporal patterns of rate of return.

Cross-sectionally, log sales can be expected to measure scale economies and capital-requirement entry barriers. The log form of the variable is adopted to reduce heteroscedasticity. The log form has been used in previous work (see Mueller [45], for example).

2) Capital growth ($\dot{K}/K$), measured by annual capital expenditures/total assets, represents the rate of capital stock accumulation. The expected sign is ambiguous (i.e., $\partial RR/\partial\dot{K}/K \gtrless 0$), since a mixture of influences induce firms to acquire more capital. First, $\dot{K}/K$ measures both capital replacements and expansion expenditures. If demand is static, a mature industry in equilibrium, capital replacements are expected to dominate. Capital replacements for this type of industry may cause a drain on current income (particularly if depreciation is inadequate). The employment of increased levels of capital inputs should drive down the marginal return to capital, causing $\dot{K}/K$ to reduce RR on the margin (i.e., $\partial RR/\partial\dot{K}/K < 0$).

The timing of returns may also cause $\partial RR/\partial\dot{K}/K < 0$. If current or one period lagged capital expenditures do not generate returns until some subsequent period, then

$\partial RR/\partial \dot{K}/K < 0$ should result. Capital expenditure on oil drilling in the petroleum industry is an example. Revenues may not begin to cover costs until about 5 to 8 years after a successful well is drilled.

Profitable opportunity may cause $\partial RR/\partial \dot{K}/K > 0$. In a rapidly growing industry (i.e., when demand outstrips capacity) marginal additions to capital may increase revenues. Rapid technological change may also create profitable opportunities through transformations of the opportunity set.

The lag structure across industries is not expected to be uniform. Degrees of freedom limitations in the time-series preclude specifying a lag structure over more than one period. Since there are no prior expectations about the length of lag structures, the model is allowed to seek its own lag between contemporaneous $\dot{K}/K$ and $\dot{K}/K$ lagged one period. The choice criterion is R^2, the proportion of explained variation in the model. A two year lag is not attempted since degrees of freedom considerations are critical.

3) Average industry R&D intensity (RD/S), measured by sales weighted R&D expenditures, measures the technological inputs to the industry. This variable is expected to have a positive impact on rate of return ($\partial RR/\partial RD/S > 0$) through improving the efficiency of input utilization and/or

improving output per unit input. RD/S may also impact on RR through increasing the commercial advantage of the firm relative to its rivals. It is a measure of internal technical investment (see Branch [12], for example). RD/S is entered lagged one period since past decisions are expected to impact on current performance. A more complicated lag structure was precluded by the length of the time period.

Data limitations are more severe for R&D expenditures than any other variable. This variable experiences a varying base across time as Compustat R&D data are relatively incomplete until the 1970's. Problems are further exacerbated by firms having the option to expense or capitalize R&D prior to 1974. RD/S is expected to contain more noise than any of the other variables. However, as is pointed out in most discussion of errors in variables, one is generally better off including a noisy variable than to neglect it altogether.[4]

4) The remaining variables for the time-series analysis are the JV horizontality measures, JV3–JV6, the principal variables of interest. These were discussed previously.

7.3.2 The Model

The discussion of the determinants of industrial rates of return indicates the following models:

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[4] See, for example, J. Johnston [30], pp. 281-291.

(5.1) $RR_{it} = b_0 + b_1 JV3_{it} + b_2 JV4_{it} + b_3 \text{Log } S_{it} + b_4 (RD/S)_{i,t-1} + b_5 (\dot{K}/K)_{i,t-1} + e_{it}$

for parent-parent horizontality relations, and

(5.2) $RR_{it} = b_0 + b_1 JV5_{it} + b_2 JV6_{it} + b_3 \text{Log } S_{it} + b_4 (RD/S)_{i,t-1} + b_5 (\dot{K}/K)_{i,t-1} + e_{it}$

for parent-child horizontality relations.[5] The time-series are run for i fixed across t. The cross-pool is run over all i,t.

It is expected that:

$b_1 > 0, b_2 < 0, b_3 > 0, b_4 > 0, b_5 \lesseqgtr 0,$

in both models.

7.4 Results from Parent-parent Horizontality Cross-pool Tests

Table 7.1 presents the cross-pool results for 15 industries covering 1965-1975. Equation (1) presents the results for the basic 5 variables from equation (5.1) above. All variables are significant and yield the expected sign. JV3's impact is positive, significant as hypothesized. We can conclude that, in general, potential for collusive behavior does exist when the parents are horizontal to one another. In subsequent specifications, however, JV3 becomes insignificant. This sensitivity to specification suggests that the

5 The subscript on $\dot{K}/K$ is represented as i,t-1. It is, however, a mixture of i,t and i,t-1, based on the prior discussion in Section 7.3.1.

Table 7.1

RR Cross-Pool Results -- Parent-Parent Horizontal, Cumulative JV Incidence (1965-1975)

Equation	C	Log S	$(RD/S)_{t-1}$	$(\dot{K}/K)^{a}_{t-1}$	JV3	JV4	CONC	COV
(1)	.013	.032	1.26	-.146	.038	-.041		
	(2.11)	(12.70)	(9.76)	(-2.11)	(3.08)	(-4.32)		
(2)	.081	.026	1.13	-.145	.014	-.028	-.001	
	(4.88)	(9.18)	(8.90)	(-2.20)	(1.15)	(-3.00)	(-4.37)	
(3)	.003	.032	1.23	-.135	.036	-.040		.0001
	(.25)	(12.67)	(9.37)	(-1.93)	(2.91)	(-4.18)		(1.04)
(4)	.069	.025	1.09	-.129	.012	-.026	-.001	.0002
	(3.68)	(9.10)	(8.46)	(-1.96)	(.89)	(-2.78)	(-4.51)	(1.52)
(5)	.099	.026	.801	-.157	.003	-.031	-.002	
	(5.65)	(9.40)	(4.28)	(-2.43)	(.28)	(-3.32)	(-5.19)	
(6)	.105	.027	.755	-.162	.002	-.031	-.002	
	(5.41)	(9.38)	(3.80)	(-2.50)	(.12)	(-3.28)	(-4.44)	
(7)	.095	.027	.823	-.169			-.002	
	(5.32)	(9.36)	(4.33)	(-2.53)			(-4.85)	
(8)	.084	.026	.885	-.147			-.002	
	(4.44)	(9.24)	(4.62)	(-2.26)			(-4.61)	
(9)	.098	.027	.788	-.163			-.002	
	(5.37)	(8.85)	(4.06)	(-2.42)			(-4.88)	

[a] $\dot{K}/K_{t-1}$ to $\dot{K}/K_{t}$ transformations for SIC'S 10.0, 20.1, and 32.2.

Note: For 15 industries; 4 industries had zero vectors for JV3. Rho values from 1965-1975 time-series.

M_1	M_2	M_3					R^2	SSE	F/d.f.
							.7400	.18043	90.54
									5,159
							.7680	.16099	87.21
									6,158
							.7418	.17921	75.67
									6,158
							.7714	.15865	75.71
									7,157
.022	.033						.7822	.15118	70.04
(2.68)	(2.94)								8,156
.026	.036	.005					.7829	.15069	62.11
(2.61)	(2.98)	(.70)							9,155
			JV3 TECH	JV4 TECH	JV3 NONTECH	JV4 NONTECH			
.022	.031		.078	−.040	.001	−.028	.7843	.14972	56.00
(2.63)	(2.16)		(1.22)	(−2.49)	(.11)	(−2.71)			10,154
			JV3 EXPL	JV4 EXPL	JV3 NONEXPL	JV4 NONEXPL			
.033	.028		.055	−.036	.099	−.027	.7880	.14715	57.25
(3.23)	(2.47)		(.36)	(−3.19)	(1.82)	(−1.91)			10,154
			JV3 ENG	JV4 ENG	JV3 NONENG	JV4 NONENG			
.022	.034		.032	−.034	.002	−.029	.7748	.15106	52.98
(2.48)	(2.89)		(.36)	(−2.12)	(.21)	(−2.93)			10,154

potential for collusion is not strong. JV4 is negative, significant as hypothesized, indicating support for the hypotheses of knowledge acquisition or market entry when the parents are not horizontally related. The other variables are consistent with the interpretations suggested in Section 7.3.1.

Basic model extensions. Equations (2), (3), and (4) in Table 7.1 introduce the market structure variables of concentration and coverage. These variables are introduced since industrial rates of return are at least partially dependent upon the competitive structure of the industries involved. Concentration, CONC, measures the extent to which a product is produced by a few firms. The expected sign is positive since the higher the industry concentration the greater the likelihood that the firms in the industry possess some degree of market power. Coverage, COV, is used as a proxy for barriers to entry. As coverage rises, there are fewer firms producing the product as a "secondary" product. This observation suggests some difficulty in entering the industry, which is consistent with barriers to entry. The expected sign is positive.[6]

F tests are employed to measure the additional explanatory power from these two variables. The F test is calculated as:

$$F_{Q-K,\ N-Q} = \frac{R^2_Q - R^2_K}{1-R^2_Q} \cdot \frac{N-Q}{Q-K}$$

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6 See, for example, Berg and Friedman [10] and Rhodes [49].

where the subscript Q refers to the equation including concentration (equation 2) or to the equation including coverage (equation 3) and the subscript K refers to equation (1).

The F test between equations (1) and (2), and between equations (1) and (3), indicate that the addition of concentration yields additional explanatory power, but that the addition of coverage does not. The values for the F test are: N = 165, Q = 7 (equations 2 and 3), and K = 6.

The calculated F statistics are: $F_{1,158} = 19.06$ between equations (1) and (2), significant at the .01 level. $F_{1,158} = 1.10$ between equations (1) and (3), insignificant at the .05 level.

Equation (4) includes both concentration and coverage. It is possible that concentration and coverage taken together, through their interaction, may add explanatory power even though coverage by itself does not. The F test rejects this possibility ($F_{2,157} = 2.33$ between equations (2) and (4), insignificant at the .05 level). All subsequent equations include concentration and omit coverage based on these F test results. A summary of the F tests appears in Table 7.2.

From equation (2) we can conclude that rates of return are negatively related to concentration once other factors, such as scale factors captured in Log S, are accounted for.

In equations (3) and (4) the coverage ratio is positive, but insignificant, indicating that barriers to entry are captured in other variables, that coverage is not a good proxy, or that coverage exerts little influence on industrial rates of return.

Table 7.2

F Tests for Explanatory Power of Additional Variables--Parent-Parent Horizontality Cross-Pool Equations

Equation A to B	Degrees of Freedom	F value	Significance
1 to 2	1,158	19.06	.01
1 to 3	1,158	1.10	ns[a]
2 to 4	1,157	2.33	ns
2 to 5	2,156	5.08	.05
5 to 6	1,155	.49	ns

[a] ns = not significant.

The results in equation (4) contrast some findings in Berg and Friedman [10] using the technological-nontechnological indexes. Their estimated model is:

$$RR = .002 - \underset{(-4.67)}{.037}\ JV1 + \underset{(3.00)}{.022}\ JV2 + \underset{(10.54)}{.025}\ \text{Log } S + \underset{(13.68)}{2.00}\ (RD/S)_{t-1}$$

$$- \underset{(-3.00)}{.144}\ (\dot{K}/K)_{t-1} - \underset{(-.97)}{.002}\ CONC + \underset{(1.60)}{.002}\ COV$$

$R^2 = .88$, $F_{10,160} = 118.17$.

They found concentration to be insignificant, but coverage (barriers to entry) to be significant.

JV indexes and number of industries are the only essential differences between their equation[7] and equation (4) in Table 7.1. The explanation for the different results must lie in the different indexes or in the exclusion of some industries. If it is the JV indexes, then horizontality measures appear to substitute as a barrier to entry proxy.

Table 7.3 presents correlations between the cumulative indexes, JV1 - JV4, and the market structure variables concentration and coverage. Since JV1 is more closely related to JV4 by pairwise correlation and JV2 is more closely related to JV3, the comparisons will be made in that order. Between JV1 and JV4 the correlations appear similar for concentration but differ in sign for coverage,

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7 Berg and Friedman's [10] regression covers the period 1965-1973, while the current work covers 1965-1975. However, horizontality tests for 1965-1973 produced similar results.

Table 7.3

Correlation Analysis Between JV1 - JV4
and Market Structure Variables

	JV1	JV2	JV3	JV4	CONC	COV
JV1	1.0	.78	.64	.97	.28	.04
JV2		1.0	.93	.84	.002	-.095
JV3			1.0	.67	-.009	.007
JV4				1.0	.24	-.065
CONC					1.0	-.017
COV						1.0

though neither is statistically different from zero. Between JV2 and JV3 the signs reverse for all correlations with market structure variables, though none are statistically different from zero. Given the sign reversals it is possible that JV3 and JV4 react differently with concentration and coverage than JV1 and JV2, and that they substitute for barriers to entry. But, the general insignificance of the correlations suggests the exclusion of industries as a plausible explanation.

Equations (5) and (6) introduce the industry dummy variables described in Table 7.4. The purpose of these industry dummy variables is to test for differential impacts on industry average rates of return by broad classes of industries. It is hypothesized that rates of return should differ according to the underlying base of the industry.

The industry classes are represented by dichotomous variable; they are (1)M_1 distinguishes industries by resource base, those that rely heavily on mining or exploration and drilling as a source of income or as a major input into their production processes versus those that do not; (2)M_2 distinguishes industries by technological base, those that rely heavily on R&D and technological development versus those that do not; and (3)M_3 distinguishes industries by engineering base, those that use engineering processes extensively in production versus those that do not. Since some industries appear in more than one classification, the classification scheme avoids problems with singularity.

Table 7.4

Industrial Groups Dummy Variables

Extraction, Exploration and Drilling - Resource Base:

M_1 = 1 for SIC's 10.0, 13.1, 29.0, 33.1, 33.2

= 0 for SIC's 20.1, 28.1, 28.3, 28.4, 32.1, 32.2, 34.0, 35.1, 35.2, 36.1, 36.2, 37.1, 37.2, 38.0

High vs. Low Technology Base (1 = high, 0 = low):

M_2 = 1 for SIC's 28.1, 28.3, 28.4, 36.1, 36.2, 37.1, 37.2, 38.0

= 0 for SIC's 10.0, 13.1, 20.1, 29.0, 32.1, 32.2, 33.1, 33.2, 34.0, 35.1, 35.2

High vs. Low Engineering Base (1 = high, 0 = low):

M_3 = 1 for SIC's 34.0, 35.1, 35.2, 36.1, 36.2, 37.1, 37.2, 38.0

= 0 for SIC's 10.0, 13.1, 20.1, 28.1, 28.3, 28.4, 29.0, 32.1, 32.2, 33.1, 33.2

The results from equations (5) and (6) indicate that industrial rates of return vary positively with resource base and positively with technological base. Table 7.2 contains the F tests for the addition of these variables. The F test between equations (2) and (5) is significant at the .01 level. The addition of the engineering dummy, M_3, gives no additional explanatory power ($F_{1,555} = 0$ between equations (5) and (6)). It is therefore exluded from further tests.

Equations (7) to (9) test for shifts in the slope coefficients of JV3 and JV4 by industry classes (M_1, M_2, and M_3). This is a test of linear restrictions on JV3 and JV4. The restricted model, equation (5), represents the following null hypothesis:[8]

H_0: $b_{M_2 JV3} = b_{M_{not2} JV3}$,

and

$b_{M_2 JV4} = b_{M_{not2} JV4}$,

while the unrestricted model, represented by equation (7), can be expressed as the alternative hypothesis:

H_1: $b_{M_2 JV3} \neq b_{M_{not2} JV3}$,

and

$b_{M_2 JV4} \neq b_{M_{not2} JV4}$.

The test for the validity of the restriction is an F test, where

$$F = \frac{[SSE_{H_0} - SSE_{H_1}]/c(p-1)}{SSE_{H_1}/(N-2K)}$$

8 This section follows J. Johnston [30], pp. 192-207.

where:

p = the number of classes = 2,

c = the number of coefficients in the subset = 4,

N = the number of observations = 165,

K = the number of variables in the unrestricted model = 11.

The F statistic is:

$F_{4,143} = .34.$

We can conclude that the restricted model is a better specification. It does not appear, therefore, that the influence from horizontal or nonhorizontal JVs on industrial rates of return differs according to the technological base of the industry.

The same F tests are applied to the extraction, M_1, and engineering, M_3, industry clasisfications, equations (8) and (9) respectively. Similar results obtain; we can reject any additional explanatory power from the unrestricted models. The F statistics are:

M_1: $F_{4,143} = .97,$

M_2: $F_{4,143} = .02.$

Even though equations (7) to (9) are more general specifications, they appear to be inferior to the restricted model, equation (5).

An interesting result does emerge from equations (7) to (9), however. When JV3 and JV4 are separated by industry groups, JV3 is insignificant in all but one case. The sensitivity of JV3 to model specification tends to support the contention that market power

augmentation, indicating possible collusion, does not seem severe. This interpretation again contrasts the previous analysis by Pfeffer and Nowack [46] at the 2-digit SIC level.

JV4, on the other hand, tends to be quite robust. It retains significance and negativity under all specifications at the .05 level. Thus, the knowledge acquisition and market entry interpretations receive considerable support.

Policy implications derive from the preceding analysis. First, the threat of antitrust action and past cases, such as the Penn-Olin case, may act as a deterrent to potentially collusive JVs. Second, antitrust authorities should watch horizontal JVs more closely than nonhorizontal ones, and more appropriately focus on 3-digit SIC parent linkages rather than 2-digit SIC linkages since choice of SIC level can dramatically alter results and influence interpretations.

7.5 Results from Parent-child Horizontality Cross-pool Tests

The preceding sections examined differential impacts on industry average rates of return from parent-parent horizontality indexes of JV activity. The conclusion was drawn that market power augmentaion, possibly indicating collusion, does not appear to strongly influence JV activity. There is, however, another means in which market power augmentation may be captured - through the parent firm's relationship with the JV (child). Pfeffer and Nowack [46], for example, focused on parent-child relationships.

It is expected that parent-parent horizontality should have a stronger potential for uncovering market power augmentation than

parent-child horizontality. In the first place, any direct exercise of market power through the JV may be more visible and thus more prone to antitrust action. Secondly, a JV, by definition, is a new firm with no preexisting market share or market power (except, for example, for that which may accrue through patent protection). Any market power that exists belongs to the parents. Collusion through the JV, then, would likely represent a division of market or combination of parents' market share, again in the more visible form.

It is expected therefore that JV5, parent-child horizontal, is less likely to capture market power influences than JV3, parent-parent horizontal. Consistent with the market power hypothesis, however, JV5 is expected to be positive.

JV6, on the other hand, gives the most direct test of new market entry via JV of all the JV indexes. Since the firms in the sample are large firms, the occurrence of a large firm with a child in another industry, JV6, is interpreted as indicating entry by the large firm into another market. New market entry is expected to imply knowledge acquisition activities and thus cause a negative impact on industry average rates of return (RR/ JV6 0).

Cross-pool results - Basic 5 variables. Table 7.5 presents the cross-pool results for 17 industries covering 1965-1975.[9] Equation

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9 Two industries out of the 19 included in Berg and Friedman [10] are omitted since the JV5 vector contains all zeros. The zero vectors make it impossible to estimate the time-series regressions for these two industries.

Table 7.5

RR Cross-Pool Results -- Parent-Child Horizontality Measures (1965-1975)

Equation	C	JV5	JV6	Log S	$(RD/S)_{t-1}$	$(\dot{K}/K)_{t-1}$	CONC	COV
(1)	.003	-.012	-.017	.032	1.18	-.059		
	(.42)	(-1.12)	(-1.87)	(11.18)	(10.34)	(-1.15)		
(2)	.045	-.005	-.011	.029	1.22	-.054	-.0008	
	(3.64)	(-.46)	(-1.95)	(10.26)	(11.08)	(-1.10)	(-4.26)	
(3)	-.010	-.006	-.013	.032	1.14	-.052		.0002
	(-.90)	(-.55)	(-2.22)	(10.91)	(9.80)	(-1.01)		(1.57)
(4)	.029	.022	-.013	.028	1.17	-.045	-.0008	.0002
	(2.05)	(.25)	(-2.44)	(9.92)	(10.50)	(-.92)	(-4.46)	(2.05)
(5)	-.016	.008	-.015	.031	1.37	-.067	-.0005	.0004
	(-.80)	(.07)	(-2.73)	(10.57)	(10.74)	(-1.37)	(-2.72)	(3.18)
(6)	-.020	-.004	-.015	.034	1.26	-.066	-.0006	.0004
	(-.95)	(-.33)	(-2.69)	(9.30)	(8.17)	(-1.37)	(-2.99)	(2.57)
(7)	-.022	-.001	-.015	.031	1.40	-.063	-.0004	.0005
	(-1.04)	(-.12)	(-2.75)	(10.46)	(10.55)	(-1.29)	(-1.72)	(3.30)
(8)	-.038			.034	1.41	-.034	-.0005	.0006
	(-2.01)			(12.41)	(11.82)	(-.76)	(-2.86)	(4.20)
(9)	-.047			.032	1.53	-.049	-.0005	.0006
	(-2.52)			(11.86)	(13.31)	(-1.13)	(-2.80)	(4.92)
(10)	-.039			.032	1.48	-.032	-.0003	.0005
	(-1.80)			(10.80)	(11.32)	(-.60)	(-.161)	(3.84)

M_1	M_2	M_3					R^2	SSE	F/d.f.
							.7139	.3158	92.80
									5,181
							.7450	.1961	87.66
									6,180
							.7431	.2129	78.38
									6,180
							.7508	.1916	77.07
									7,179
.024							.7629	.1823	71.62
(3.02)									8,178
.029	.012						.7651	.1806	64.06
(3.27)	(1.27)								9,177
.023		−.006					.7640	.1815	63.67
(2.94)		(−.88)							9,177
			JV5 TECH	JV6 TECH	JV5 NONTECH	JV6 NONTECH			
.025			−.074	.022	.097	−.032	.8124	.1442	76.23
(2.52)			(−4.74)	(2.85)	(3.90)	(−4.57)			10,176
			JV5 EXPL	JV6 EXPL	JV5 NONEXPL	JV6 NONEXPL			
.025			.116	−.032	−.064	.019	.8172	.1406	78.69
(2.48)			(4.15)	(−4.19)	(−4.70)	(2.67)			10,176
			JV5 ENG	JV6 ENG	JV5 NONENG	JV6 NONENG			
.028			−.118	−.016	−.001	−.017	.7754	.1727	60.78
(3.43)			(−2.20)	(−.75)	(−.10)	(−3.60)			10,176

(1) presents the results for the basic 5 variables in equation (5.2). The variables Log S, $(RD/S)_{t-1}$, and $(\dot{K}/K)_{t-1}$ yield the expected sign and are all significant. The interpretation follows that of the parent-parent horizontality tests.

JV6 is negative, significant as expected, supporting new market entry for those JVs. The number of nonhorizontal JVs relative to the number of horizontal ones for both parent-parent and parent-child indexes (see Table 3.4) further supports the potential importance of new market entry as a motivation to form a JV.

JV5, parent-child horizontal, is negative, but insignificant. Thus, the parent-child horizontal index gives no indication of market power augmentation. As expected, the parent-parent horizontal index is more powerful for uncovering market power augmentation.

Basic Model Extensions. The introduction of concentration and coverage, the two market structure variables, does not alter the equation (1) results for JV5 and JV6. Table 7.6 presents the F tests for explanatory power of additional variables. The F test between equations (1) and (2) indicates that the addition of concentration yields improved explanatory power ($F_{1,180} = 18.14$, significant at the .01 level). The F test between equations (1) and (3) indicates that coverage by itself does not add explanatory power. However, when concentration and coverage are introduced together, coverage does yield additional explanatory power ($F_{1,179} = 4.16$, significant at the .05 level). Subsequent specifications include both concentration and coverage.

Table 7.6

F Tests for Explanatory Power of Additional Variables

Equation A to B	Degrees of Freedom	F	Significance
1 to 2	1,180	18.14	.01
1 to 3	1,180	2.47	ns[a]
2 to 4	1,179	4.16	.05
4 to 5	1,178	9.08	.01
5 to 6	1,177	1.65	ns
5 to 7	1,177	.83	ns

[a] ns = not significant.

Concentration is negatively related to industry average rates of return for the reasons discussed in Section 7.4. Coverage is positively related to industry average rates of return. This result is interpreted as indicating that rates of return increase with barriers to entry and that a specification using JV5 and JV6 has not already captured this effect.

This result on coverage is consistent with Berg and Friedman's [10] finding using the technological-nontechnological indexes, but the regressions using the parent-parent horizontality indexes indicated that coverage should not be included in the specification. Correlations between JV3 - JV6 and the market structure variables, presented in Table 7.7, indicate that the relation between JV3 and JV4 with the market structure variables and the relation between JV5 and JV6 with the market structure variables differ. These differences occur for both sign and magnitude, particularly when horizontal JV indexes and nonhorizontal JV indexes are compared separately. Thus, the previous interpretation that JV3 and JV4 may act as a barriers to entry proxy gains some support.

Equations (5) to (7) introduce the industry group dummy variables from Table 7.4. When JV5 and JV6 are used to represent JV indexes, only M_1, Resource base, adds explanatory power. Resource based industries appear to have a positive, significant impact on industry average rates of return; neither M_2 nor M_3 yields additional explanatory power. This is in partial contrast to results

Table 7.7

Correlation Analysis Between JV3 - JV6
and Market Structure Variables

	JV3	JV4	JV5	JV6	CONC	COV
JV3	1.0	.67	.45	.77	-.009	.007
JV4		1.0	.86	.95	.24	-.06
JV5			1.0	.69	.24	-.23
JV6				1.0	.16	.05
CONC					1.0	-.017
COV						1.0

with parent-parent horizontality indexes where rates of return varied positively with technology base, M_2, as well.

Equations (8) to (10) test for differential impacts from JV5 and JV6 by industry groups. Table 7.8 presents the F test results for shifts in the slope coefficients. The table indicates that JV impacts vary with resource base of the industry ($F_{4,176} = 11.62$) and with technology base ($F_{4,176} = 13.04$). These two equations, (8) and (9), appear to be the best and most general specifications of the RR model when JV5 and JV6 are used.

In equation (5), JV5 was insignificant; the impact from JV5 becomes significant when industry group effects are taken into account, equations (8) and (9). Equation (8) indicates that JV5 is negative, significant for technologically based industries and positive, significant for nontechnologically based industries. The negativity of JV5-TECH indicates that market power augmentation for this group of JVs is less likely, even when parent-child horizontality exists. The positive effect from JV5-NONTECH suggests that market power augmentation, possibly indicating collusion, is possible for this group of JVs.

The result for JV5-TECH is consistent with knowledge acquisition from a smaller firm within the industry (parent-parent horizontal) or with knowledge acquisition that is applicable to the firm's own industry, but developed externally (parent-parent nonhorizontal). Since 230 of 289 JVs in the technologically based industries involve

Table 7.8

F Tests for Model Specification
(Shifts in Slope Coefficients of JV Variables)

Between A and B	Degrees of Freedom	F	Significance
5 and 8	4,176	11.62	.01
5 and 9	4,176	13.04	.01
5 and 10	4,176	2.44	ns[a]

[a] ns = not significant.

parents not horizontally related, knowledge acquisition from firms external to the industry can be expected to dominate.

JV6 is positive, significant for technologically based industries. This result is inconsistent with expectations regarding market entry. If these JVs involve vertical relationships between the parents or occur in firms' secondary product lines, this result may indicate market power augmentation. Since vertical relationships and secondary product lines are not included in the current study, this explanation cannot be ruled out. These JVs may, however, represent a profitable application of technological knowledge in a nontechnologically based industry.

The negative, significant coefficient for JV6 in nontechnologically based industries is interpreted as consistent with new market entry. One explanation lies in the life cycle of an industry. The nontechnologically based industries are generally more mature industries, past initial growth stages. It is reasonable, then, for them to look to the technologically based industries for new investments and for this to temporarily depress their rates of return.

Equation (9) results also yield significance for all JV variables and, in a sense, are a mirror image of equation (8) results. Table 7.4 shows that resource based industries are usually nontechnologically based industries, though a perfect overlap does not exist. Previous interpretations, but in reverse, therefore apply.

7.6 Conclusions

The foregoing results indicate that market power augmentation, which may indicate collusion, is more probable for parent-child horizontal JVs in resource based industries, JV5-EXPL, and for parent-child nonhorizontal JVs in nonresource based industries, JV6-NONEXPL. Knowledge acquisition and new market entry are supported for parent-child horizontal JVs in nonresource based industries, JV5-NONEXPL, and parent-child nonhorizontal JVs in resource based industries, JV6- EXPL.

In contrast, results using the parent-parent indexes indicated that the specification without the industry group splits on the JV coefficients is superior. This suggests that JV3 and JV4 exhibit more homogeneity across industry groups. If so, JV3 and JV4 are less sensitive to specification and are thus preferable measures of JV activity.

The results using the parent-parent horizontality indexes indicated a weak potential for market power augmentation when parent-parent horizontality exits. That is, potential for collusion does not seem severe. Knowledge acquisition was supported for parent-parent nonhorizontality.

Antitrust policy implications from the two preceding sections suggest that antitrust authorities should focus their attentions on JVs which involve parent-parent horizontal relationships and on JVs which involve parent-child horizontal relationships in nontechnologically based industries. When evaluated at the mean, the impact from

JV5 is strongest for resource based industries (a JV causes a .02 increase in mean rates of return for this group, .009 at the mean for all nontechnologically based industries). Special attention may be merited for this group. Finally, vertical relationships may also merit attention, though their impact was not considered here.

CHAPTER 8

CROSS-INDUSTRY STUDIES: R&D IMPACTS

Chapter 6 found R&D substitution at the firm level for the Chemicals and Engineering industry groups. Chapter 7 examined the effects of JV activity on industry average rates of return, but not the effects on industry average R&D expenditures. The analysis now turns to JV activity's effect on industry average R&D expenditures.

Whereas substitution is indicated at the firm level, JVs may stimulate commitments to R&D at the industry level. Grabowski [22] and Phillips [47] have noted a pattern in R&D at the firm level, which Grabowski coined "success-breeds-success." Grabowski argues that success in R&D projects leads to further R&D expenditures by a firm. An analogous argument can be applied to JV activity at the industry level. Successful knowledge acquisition and application through a JV may be expected to lower internal resistance to future involvement in JVs. Such successes, in turn, may induce rival firms to conduct a greater amount of R&D than they would in the absence of JVs. Thus, successful JVs (reducing one firm's internal R&D expenditures) could induce increased R&D activity industry wide. Besides this rivalry effect, JV activity may also serve as a stimulus to small firms to increase their R&D expenditures. While this small

firm R&D augmentation cannot be tested, the effect on rival firms can be examined. The principal hypothesis of this chapter, then, is that R&D complementarity occurs at the industry level.

8.1 A Model of R&D Determination at the Industry Level

It is hypothesized that JV and R&D are complementary at the industry level for important segments of JV activity. These segments are expected to be technologically oriented JVs, JVs when parent-parent nonhorizontality exists, and JVs when parent-child nonhorizontality exists. The complementarity effects through nonhorizontality relations are hypothesized since they may represent new market entry and acquisition of knowledge outside the firm's immediate expertise. R&D complementarity will be supported by a positive sign for the JV coefficients (i.e., $\partial RD/\partial JV1>0$, $\partial RD/\partial JV4>0$, and $\partial RD/\partial JV6>0$).

The remaining indexes of JV activity are expected to exert no influence (insignificant coefficients) on industry average R&D expenditures or to cause a negative effect. For nontechnologically oriented JVs (JV2), insignificance is expected since there need be no relation between nontechnological JVs and R&D. A negative effect may be interpreted as indicating R&D substitution at the industry level. Firms which engage in nontechnologically oriented JVs may seek activities which circumvent the need to conduct R&D, thus causing R&D substitution.

Variables other than the JV indexes that appear in the model are size and profitability. These variables appear consistently in most

studies of R&D.[1] In the current model, size is measured by sales and can be interpreted as capturing effects from scale economies, entry barriers, and demand growth (when used across time).

The size effects need not increase linearly. Evidence from Chapter 6 suggests that they do not when firms are considered. This same effect may also occur when industry average R&D expenditures are considered. To allow for these possible nonlinearities, a specification using sales (S) and sales squared (S^2) is employed. The expected signs are $\partial RD/\partial S>0$ and $\partial RD/\partial S^2 \gtrless 0$.

Profitability can be represented by cash flow (as in Chapter 6) or as after tax rate of return on invested capital (the dependent variable in Chapter 7). The expected sign is positive. Experimentation with these two measures of profitability and with various single period lag structures (multiple period lag structures were precluded by limited degrees of freedom in the time-series) indicates that after tax rate of return, lagged one period, (RR_{t-1}) yields better results than the cash flow measure or contemporaneous rate of return. This result suggests that high past profitability leads to greater resources devoted to current R&D, but perhaps as a result of high past productivity in R&D as Branch [12] indicates.

The previous discussion leads to the following specification for the basic model, prior to an adjustment for heteroscedasticity and

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1 See, for example, Branch [12], Scherer [52], and Mueller [45].

model refinements using market structure variables and slope shifts for the JV variables:

(8.1) $RD_{it} = b_o + b_1JV_{jit} + b_2JV_{kit} + b_3S_{it} + b_4S^2_{it} + b_5RR_{i,t-1} + e_{it}$

where:[2]

$i = 1,\ldots,I$ for industries; $t=1,\ldots,11$ for 1965-1975;

$j = 1,3,5$; and $k=2,4,6$

for the model using cumulative indexes. The model using beginning dates, unadjusted for heteroscedasticity, is represented as:

(8.2) $RD_{it} = b_o + b_1JS_{jit} + b_2JS_{kit} + b_3S_{it} + b_4S^2_{it} + b_5RR_{i,t-1} + e_{it}$

where:

$i = 1,\ldots,I$ for industries; $t=1,\ldots,11$ for 1965-1975;

$j = 1,3,5$; and $k=2,4,6$.

Note the notation adopted for the above models: indexes beginning with JV (equation 8.1 above) represent cumulative indexes[3] and indexes beginning with JS (equation 8.2 above) represent beginning date indexes. This notation will be used throughout the chapter.

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2 JV_{jit} and JV_{kit} are measures of the level, not intensity, of JV activity in equation (8.1). A similar statement applies to equation (8.2).

3 Section 7.1 discussed issuing regarding the use of cumulative versus beginning data indexes.

By a comparison of the results under the two specifications, equations (8.1) and (8.2), some indication of appropriate lag structure for the effect of JV activity on R&D can be inferred. That is, we will be able to infer whether it is current JVs or past JVs which seem to have the greatest impact on R&D expenditures, since the cumulative indexes reflect the effects from past, as well as current, JV activity.

The above models are estimated using the cross-pool methodology discussed in Section 7.2. The same error term assumptions of time-series autocorrelation and cross-section heteroscedasticity are made. Both R&D level models, which do not include the heteroscedasticity adjustments, and R&D intensity (R&D divided by sales, RD/S) models are estimated. In the R&D level models the JV indexes are represented by incidence measures, the level of JV activity; in the R&D intensity models the JV indexes are represented by intensity measures (see section 3.3.2).

8.2 Statistical Results - R&D Level Models

There are six specifications due to the six different pairs of JV indexes, plus successive model refinements using market structure variables, industry group variables from Table 7.4, and slope shifts according to industry groups for the six pairs of JV indexes. Due to these various specifications, a large number of equations were estimated. To avoid inundating the reader with such a large number of equations, only those equations which produced the best results will be reported.

Principal focus on interpretations will be reserved for the R&D intensity models (i.e., the ones with the heteroscedasticity adjustments). Further, model refinements using industry group variables and slope shifts only appear in the R&D intensity models. There are, however, some interesting results from the R&D level equations. Furthermore, these results are more comparable to the firm level R&D equations in Chapter 6. It is important to note for the interpretation of the R&D level equations that heteroscedasticity does not cause bias, though the coefficient estimates may be inefficient.

Tables 8.1 and 8.2 present the R&D level equations for the basic 5 variables in equations (8.1) and (8.2) above and the market structure concentration variable. The results for lagged rate of return (RR_{t-1}) are positive, significant in all equations. These results suggest that high past industry average profitability is associated with higher average R&D expenditures for the firms in the industry.

Sales (S) is positive, significant for all equations, while sales squared (S^2) is negative, significant for all equations.[4] Thus, industries with larger average firm size tend to devote more resources to R&D, but at a diminishing rate. This result probably reflects a mixture of effects from industries with larger average

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[4] Since some industries were excluded, this result must be interpreted with some care. There may be some selection bias.

Table 8.1

R&D Level Cross-Pool Results -- Cumulative JV Indexes

Equation	C	S	S^2	RR_{t-1}	Conc	JV1	JV2	R^2	SSE	F/df
(1)	-16.56	.014	-1.5E-6	72.82	.225	21.11	-11.39	.9424	6471.99	551.07
	(-10.51)	(9.67)	(-3.74)	(12.17)	(7.17)	(18.07)	(-11.50)			6,202
						JV3	JV4			
(2)	-26.40	.015	-1.9E-6	92.36	.364	7.89	7.53	.8779	12400.29	189.43
	(-9.65)	(6.37)	(-2.82)	(8.62)	(6.41)	(1.17)	(4.64)			6,158
						JV5	JV6			
(3)	-30.58	.015	-2.2E-6	101.35	.426	17.41	2.75	.8919	11359.41	247.50
	(-12.39)	(8.91)	(-4.66)	(11.20)	(9.49)	(6.46)	(1.57)			6,180

Table 8.2

R&D Level Cross-Pool Results -- Beginning Date Indexes

Equation	C	S	S^2	RR_{t-1}	Conc	JS1	JS2	R^2	SSE	F/df
(1)	-23.37	.021	-2.8E-6	91.34	.283	51.31	2.52	.8697	16025.05	224.90
	(-9.60)	(10.46)	(-5.13)	(7.81)	(5.49)	(5.63)	(.30)			6,202
						JS3	JS4			
(2)	-20.40	.017	-1.9E-6	56.53	.329	16.37	44.26	.8457	13822.71	144.35
	(-7.53)	(6.47)	(-2.70)	(3.39)	(5.74)	(1.05)	(6.36)			6,158
						JS5	JS6			
(3)	-24.39	.023	-3.5E-6	89.70	.283	9.98	36.36	.8660	15850.25	193.97
	(-9.66)	(10.92)	(-6.08)	(9.52)	(5.13)	(.83)	(5.26)			6,180

reflects a mixture of effects from industries with larger average firm size and larger R&D expenditures, such as Basic Chemicals and Petroleum Refining, and other industries with larger average firm size but smaller R&D expenditures, such as General Food and Iron and Steel (see Table 8.3).

Concentration is positive, significant in all equations, indicating that more concentrated industries tend to devote more resources to R&D. Thus, such factors as barriers to entry and scale economies, which can lead to higher concentration, may induce greater R&D expenditures through increased potential for firms to profit from their R&D efforts (e.g., a rationale for higher concentration would be less erosion of market share through imitation by competitors).

Table 8.4 presents a summary of the signs and significance of the JV indexes that appear in Tables 8.1 and 8.2. For the technological-nontechnological measures, complementarity is indicated for technologically oriented JVs, whether the cumulative index or the beginning date index is used. Substitution is indicated for non-technological JVs when the cumulative index, JV2, is used and an insignificant effect when the beginning date index is used, JS2.

The JV1 and JS1 results are interpreted to mean that knowledge acquisition through such JVs creates greater rivalry within the industry and thus stimulates those firms which do not engage in JVs to devote more resources to their internal R&D. These results would also be consistent with a hypothesis that smaller firms increase their R&D expenditures due to the opportunity to capitalize on

Table 8.3

Ranking of Average R&D Expenditures, Average R&D Intensity, and Average Size of 2 1/2-digit SIC Industries

Industry Description	Average R&D Expenditures[a]	Ranking	Average R&D Intensity	Ranking	Sales[a]	Ranking
Metal mining	2.558	15	.0194	12	144.87	16
Extraction of petroleum & gas	.271	19	.0022	19	108.88	18
General food	5.490	12	.0083	17	768.19	4
Basic chemicals	49.866	1	.0324	4	1582.53	2
Ethical drugs	21.308	3	.0529	2	413.36	11
Paint, agricultural chemicals, NEC	3.975	14	.0288	5-6	151.65	15
Petroleum refining	15.025	5	.0072	18	2328.37	1
Glass and nonmetallic containers	9.488	10	.0209	11	471.74	10
Cement, clay, gypsum, NEC	1.801	18	.0114	15	179.27	13
Iron and steel	5.052	13	.0096	16	592.29	6
Nonferrous metals	7.669	11	.0167	14	486.99	9
Metal containers & fabricated metals	2.016	16	.0175	13	125.21	17
Nonelectrical machinery, general	13.384	6	.0265	8	531.97	8
Nonelectrical machinery, specialty	1.960	17	.0220	10	94.52	19
Electrical machinery	18.807	4	.0273	7	696.26	5
Electronics, communication, and computers	10.744	8	.0475	3	219.85	12
Autos and auto parts	33.756	2	.0288	5-6	1173.55	3
Aircraft & transportation equipment	13.118	7	.0231	9	561.27	7
Scientific instruments & measuring devices	9.723	9	.0566	1	173.22	14

[a] Millions of dollars.

Table 8.4

Summary of Sign and Significance of
JV Variables in R&D Level Equations

Variable	Sign	Significance[a]
JV1	>0	.01
JV2	<0	.01
JS1	>0	.01
JS2	>0	NS
JV3	>0	NS
JV4	>0	.01
JS3	>0	NS
JS4	>0	.01
JV5	>0	.01
JV6	>0	NS
JS5	>0	NS
JS6	>0	.01

[a] All variables significant at α = .01 or not significant at α = .05 (NS).

inventions through JVs; however, this was not tested due to the sample.

The JV2 result indicates that resources devoted to R&D decline as firms within an industry more actively employ nontechnological JVs. The insignificance of JS2, however, suggests that this effect occurs as a result of past JVs, or that some lag exists in the effect of nontechnological JVs on R&D.

The JV2 result is also consistent with market power augmentation through collusion, although again not tested here. R&D is one of the principal means for firms to increase their market power without resorting to collusion. To the extent that firms can find a substitute for R&D which creates market power there is less competitive pressure to conduct R&D.

When the JV indexes which measure parent-parent horizontal versus parent-parent nonhorizontal and the JV indexes which measure parent-child horizontal versus parent-child nonhorizontal are used, complementarity between JV activity and industry average R&D expenditures is indicated when the parents to the JV are non-horizontally related (JV4 and JS4), for parent-child horizontal when the cumulative index is used (JV5), and parent-child nonhorizontal when the beginning date index is used (JS6). All coefficient signs are positive for horizontality relations, but the ones mentioned were the only ones significant. Thus, no indication of substitution derives from the horizontality measures in the R&D level equations.

Taken together these results support industry level complementarity between JV activity and R&D expenditures. We can conclude, therefore, that there is a stronger tendency for JVs to cause increases in R&D spending through increased rivalry than for substitution to occur. This is further supported by the relatively larger number of JVs in the categories indicating complementarity.

8.3 Model of R&D Intensity

Section 8.2 showed that JV activity tends to induce increased R&D spending in an industry. However, the complementarity hypothesis can also be phrased in terms of R&D intensity, the amount firms spend relative to their size. R&D intensity, further, has been the focus of many R&D studies.[5]

There are two possible arguments for using R&D intensity, measured by R&D divided by sales (RD/S). The first argument states that the researcher should measure the determinants of R&D spending, but that R&D level equations are heteroscedastic. Therefore, one must deflate R&D dollars, as well as the independent variables, to increase the efficiency of the estimates. As Kuh and Meyer [34] point out, simple deflation will normally result in homoscedastic disturbances; also, Scherer [51] has shown that simple deflation works well for R&D equations.

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[5] See, for example, Kamien and Schwartz [31] for a review of such studies.

The second argument for using an intensity measure is that the researcher should be interested in R&D spending relative to sales, RD/S, and thus the model should be formulated initially in ratio form. Since the resultant models are essentially the same, the second argument is adopted, but after the model development under a heteroscedastic adjustment is discussed. Furthermore, interpretations on RD/S are interesting in themselves. The correlation between RD and RD/S for the sample is .34, low enough to merit separate interpretations.

RD/S model from heteroscedasticity adjustment

If we take the argument that R&D level is the primary interest, we can get to the estimated RD/S model through adjusting the following equation for heteroscedasticity, following Kuh and Meyer [34] and Scherer [51]:[6]

$$\text{(8.3)}\quad RD_{it} = b_0 + b_1 JV1\#_{it} + b_2 JV2\#_{it} + b_3 S_{it} + b_4 S^2_{it} + b_5 NI_{i,t-1} + e_{it},$$

$$i = 1,\ldots,I; t = 1,\ldots,T.$$

where:

JV1# and JV2# are the number of JV occurrences, not the intensity measures, and NI is net income, not scaled by assets.

6 The result is shown for the equation containing JV1 and JV2 only. The same adjustment would apply to all six JV specifications.

One heteroscedastic adjustment is to use a common deflator, sales in this case, for all variables. Kuh and Meyer [34], however, out that it is more appropriate to deflate each variable by its most closely related deflator. Using this result, the JV variables are deflated by the number of firms; also NI is deflated by assets, while the other variables are deflated by sales.

One other assumption is necessary. We will initially assume that $b_0 = 0$. Without this assumption we would be left with a model containing S and 1/S, which raises problems of multicollinearity.

The heteroscedastic adjusted model is:

$$(8.4)\quad (RD/S)_{it} = b_0 + b_1 JV1_{it} + b_2 JV2_{it} + b_3 S_{it} + b_4 RR_{i,t-1} + e_{it},$$
$$i = 1,\ldots,I;\ t = 1,\ldots,T,$$

which would also be the model formulated directly in ratio form.

A further statistical problem arises with this formulation, however. The dependent variable, RD/S, contains S and S appears as an independent variable. If RD and S were unrelated, correlation equals zero, then RD/S and S would be negatively related by virtue of the relation between S and 1/S. Thus, even though the impact of size on R&D intensity is an interesting question, in multivariate analysis it is difficult or impossible to disentangle the statistical relation between S and 1/S from the impact of scale economies, barriers to entry, etc. (the market structure variables for which sales is a proxy) on R&D intensity.

As an illustration, the correlation between RD and S is .615 and the correlation between RD/S and S is -.181. These correlations may

simply derive from the relation between S and 1/S; that is, the relation between S and 1/S dominates. Or, industries with smaller firms are more R&D intensive. This second interpretation fits the Ethical Drugs industry but does not fit Basic Chemicals (see Table 8.3). Thus, ambiguity remains.

Multivariate analysis of the RD/S equations produced consistently negative signs for S, nearly all of which are significant. This, of course, could just be reflecting the S and 1/S relation. What is even more troublesome is the insignificance of the intercept. Under the adjusted model the intercept would be interpreted as the coefficient of sales. It is difficult to rectify this result with the S, S^2 specification from the equations in level form.

The problems in using a specification including S led to the adoption of the following formulation, excluding S:[7]

(8.5) $(RD/S)_{it} = b_0 + b_1 JV1_{it} + b_2 JV2_{it} +$

$b_3 RR_{i,t-1} + e_{it},$

$i = 1,\ldots,I;\ t = 1,\ldots,T.$

In terms of a heteroscedastic adjusted model, this equation follows from a level specification excluding the S^2 term, but employing all other assumptions.

Much of the concern for the inclusion or exclusion of S in the RD/S model stems from the effects of firm size on JV activity.

7 There are six models. Only one is shown here.

Because of this size effect is seems desirable to include a size variable in the model so that JV variables are not acting as size proxies.

Since JV impacts are the primary focus of this study, the inclusion, or exclusion, of S is important if it causes significant changes in the JV impacts. Fortunately, the coefficients of JV variables did not appear very sensitive to the inclusion, or exclusion, of S. It is unlikely, then, that JV variables are substituting for size proxies. Since the exclusion of S does not appreciably alter results, the model with S excluded is preferable since it avoids the aforementioned statistical problem.

Furthermore, the inclusion of market structure variables give alternative proxies for scale economies and barriers to entry, alleviating much of the need for including S. The demand growth element in sales is neglected; but if sales were capturing demand growth, the sign of S (or of the intercept) should be positive, which it is not.

8.4 Statistical Results - R&D Intensity

Mueller [44] suggests that firms' allocation to R&D is inelastic to the business cycle. This derives from firms' reluctance to reduce their R&D personnel as economic conditions vary and from the long term nature of R&D commitments. Mueller's observation raises questions about the appropriateness of using the cross-pooling technique in examining the determinants of RD/S. If there is no

time-series variation in RD/S, then the gains in degrees of freedom from cross-pooling may be illusory and may artificially inflate the t statistics. On the other hand, if cross-pooling appears appropriate, several gains accure, with the most important gain being the ability to test broader specifications than would be possible with a simple cross-section.

To test whether the number of degrees of freedom in the cross-pooled model causes the variables to become significant, a cross-section test on the average of industry values across time is performed. The results from these tests are reported in Table 8.5. Since the results from these tests do not appreciably differ in sign and significance from cross-pooled results using the same specification, the additional degrees of freedom gained from cross-pooling are not responsible for the variables' significance.

As with the R&D level equations, a large number of equations were tested: first using the basic 5 variables and then with the successive refinement previously mentioned. The reporting and interpretation of equations for this chapter will be limited to those equations which produced the best results,[8] focusing on those equations with S excluded.

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8 The procedure used in Chapter 7's cross-pool model was followed here. The cross-pooling technique and model assumptions are discussed in Section 7.2 and the F test for model specification is discussed in Section 7.4. The additional equations can be supplied upon request.

Table 8.5
Cross Section of Industry Means Across Time
- RD/S with S Excluded

Equation	C	RR_{t-1}	JV1	JV2	R^2	F/df
(1)	-.022	.443	.017	-.015	.7613	15.95
	(-2.57)	(5.51)	(2.78)	(-2.93)		3,15
			JS1	JS2		
(2)	-.021	.421	.182	-.141	.7587	15.73
	(-2.31)	(5.08)	(2.91)	(-2.87)		3,15
			JV3	JV4		
(3)	-.030	.512	-.026	.011	.7341	13.81
	(-3.22)	(6.09)	(-2.57)	(2.00)		3,15
			JS3	JS4		
(4)	-.032	.522	-.224	.092	.7304	13.55
	(-3.36)	(6.14)	(-2.51)	(2.18)		3,15
			JV5	JV6		
(5)	-.027	.483	.011	-.003	.6256	8.36
	(-2.39)	(4.83)	(.74)	(-.46)		3,15
			JS5	JS6		
(6)	-.078	.494	-.025	.016	.6149	7.99
	(-2.48)	(4.88)	(-.18)	(.34)		3,15

All equations produced a common result for lagged rate of return: RR_{t-1} is positive, significant. The interpretation is that high past profitability leads to a larger proportion of resources being devoted to R&D. Thus, firms increase the dollar amount they spend (Section 8.2) and the proportion they spend as profitability increases.

Subsequent discussion focuses only on the JV indexes and their effect on RD/S.

8.4.1 Technological-nontechnological Indexes - Cumulative Measures

When JV1 and JV2 are employed as measures of JV intensity, similar results to those obtained with RD level equations obtain. JV1 is significant, positive under all specifications indicating complementarity for technologically oriented JVs. The opposite effect occurs for JV2, which we take to indicate substitution. The best specification without letting JV vary across industry groups appears to be:[9]

$$(8.6)\quad (RD/S)_{it} = -.004 + .215RR_{i,t-1} + .010JV1_{it} - .011JV2_{it} + .015M_2,$$
$$\qquad (-2.28)\ (15.33)\qquad (4.10)\qquad (-4.52)\qquad (7.76)$$

$R^2 = .7520$, $F_{5,203} = 154.68$.

When JV is allowed to vary across industry groups the best specification is (F=4.32 between equations 8.6 and 8.7, significant at the .01 level):

9 M_2 in equations (8.6) and (8.7) refers to the industry group dummy variable for technology base. See Table 7.4.

$$(8.7)\ (RD/S)_{it} = -.004 + .211\ RR_{i,t-1} + .015\ M_2 + .055(JV1\text{-}EXPL)_{it}$$
$$(-2.22)\ (15.44)\qquad (7.81)\qquad (4.98)$$
$$-.029(JV2\text{-}EXPL)_{it} + .011(JV1\text{-}NONEXPL)_{it} - .013(JV2\text{-}NON\text{-}EXPL)$$
$$(-5.69)\qquad (2.27)\qquad (-2.23)$$
$$R^2 = .7723,\ F_{6,202} = 114.17.$$

Equation (8.7) appears to be the most general specification of all equations employing JV1 and JV2. F tests which split the JV effect according to technology base and engineering base of an industry (M_2 and M_3), produced insignificance indicating th equation (8.6) above is superior to equations with slope shifts for M_2 and M_3.

Equation (8.7) above retains the same sign and significance for both technological and nontechnological JVs as appear in equation (8.6). When the impact from JV1 on RD/S is evaluated at the mean of JV1, the greatest impact from JV1 occurs in the nonresource based industries (RD/S increases by .004 for JV1-NONEXPL and by .001 for JV1-EXPL). Resource related industries can be expected to concentrate their efforts in the acquisition and usage of raw materials with less emphasis on technological development. This is reflected in Table 8.3 where of the nineteen industries covered, and ranking highest to lowest runs from one to nineteen, metal mining ranks 12th in RD/S with the remaining resource based industries below that.

The greatest impact on RD/S comes from JV2-EXPL, nontechnological JVs in the resources group. RD/S decreases by .023 when evaluated at the mean of JV2-EXPL. A large number of this resource

based group's JV2s are exploration related. If these JVs are successful we can infer that a successful history of exploration JVs reduces resource related firms dependence on technological developments. This argument is supplemented by the positive impact of JV2 on industrial rates of return. Exploration ventures when they are successful can generate significant amounts of income for some time into the future. This will decrease dependence on new developments, technological or not.

Thus, when JV activity is measured using the cumulative indexes based on technological-nontechnological orientation of JVs, it appears that complementarity is indicated for technologically oriented JVs, regardless of industry base, while substitution is indicated for nontechnologically oriented JVs, regardless of industry base. The strongest substitution effect appears to occur from nontechnologically oriented JVs in resource based industries. The strongest complementarity effect appears to occur from technologically oriented JVs in nonresource based industries.

8.4.2 Technological-nontechnological Indexes - Beginning Date Measures

The results using the beginning date intensity measures are similar to those obtained using the cumulative measure in many respects. JS1 is positive, significant under most specifications. The introduction of the group dummy variables M_1 and M_2 or M_1

and M_3 causes JS1 to become insignificant at the .05 level. JS2 is negative, significant in most equations. The introduction of M_1 causes JS2 to become positive, but insignificant.

F tests indicate the following equation is the best specification:[10]

$$(8.8)\quad (RD/S)_{it} = \underset{(-.75)}{-.001} + \underset{(14.73)}{.202}\, RR_{i,t-1} + \underset{(1.15)}{.017}\, JS1_{it} + \underset{(.57)}{.006}\, JS2_{it}$$

$$+ \underset{(.19)}{8.5E\text{-}6}\, CONC_{it} \underset{(-3.46)}{-.005}\, M_1 + \underset{(4.87)}{.007}\, M_2,$$

R^2 = .7670, $F_{6,202}$ = 110.85.

The beginning date intensity meaures, JS1 and JS2, measure the immediate impact of JVs on RD/S. They, therefore, measure the extent to which direct substitution can occur in the sense that funds allocated to JV draw down the amount allocated to R&D in the current period. Equation (8.8) above suggests that the immediate impact is insignificant once market structure, industry grouping, and the influence of past profitability are accounted for, whether the JV is technologically oriented or not.

When these results are compared to those obtained using JV1 and JV2, it can be inferred that it is past experience with JVs that influences current R&D expenditures. This is important from two perspectives. First, it offers some confirmation that the direction of

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[10] M_1 is the industry group dummy variable for resource base of an industry. See Table 7.4.

causality runs from JV to R&D. From this it follows that simultaneity is less likely to cause bias in the results. Second, some indication of lag structure emerges. The superior performance of the cumulative measures, which capture JVs from the past, suggests that lagged values of JV incidence yield a better specification.

F tests for different JV impacts by industry groups were all insignificant. Thus when single year intensity measures are used no variation in JV's impact by industry group appears to exist, though none would be expected given the insignificance of JS1 and JS2 in equation (8.8) above. This is again in contrast to the cumulative measures. The cumulative measures appear more robust than the single year measures when the technological indexes are used and it is therefore concluded that they are the superior measures in the RD/S model.

8.4.3 Parent-parent Horizontality Indexes - Cumulative Measures

In most equations employing parent-parent horizontality indexes JV3, parent-parent horizontal, is negative, significant while JV4, parent-parent not horizontal, is positive, significant. F tests suggest the following equation as the best specification when JV3 and JV4 are not allowed to vary across industry groups (i.e., the model with the linear restriction):

$$(8.9)\quad (RD/S)_{it} = \underset{(-.51)}{-.001} + \underset{(11.39)}{.193}\, RR_{i,t-1} - \underset{(-2.45)}{.009}\, JV3_{it} + \underset{(4.02)}{.005}\, JV4_{it}$$

$$- \underset{(-.11)}{.0001}\, CONC_{it} \underset{(-.44)}{-.001}\, M_1 + \underset{(6.53)}{.018}\, M_2,$$

$$R^2 = .7020,\ F_{6,158} = 62.05.$$

Complementarity appears to occur when parents are not horizontally related and substitution when the parents are horizontally related. Since JV3 and JV4 are cumulative measures, it is the effect from past JVs causing the complementarity or substitution.

The overall impact is strongest for JV4. When evaluated at the mean JV4 causes a .002 increase in RD/S while JV3 causes a .001 decrease in RD/S. Since there is a much larger number of occurrences of JV4 relative to JV3, we can conclude that complementarity dominates.

The F tests for slope shifts indicate the following equation as the best specification (F=9.73 between equations 8.9 and 8.10, significant at the .01 level):

$$\begin{aligned}
(8.10)\quad (RD/S)_{it} = {} & \underset{(2.11)}{.007} + \underset{(10.96)}{.171}\, RR_{i,t-1} - \underset{(-5.37)}{.0004}\, CONC_{it} + \underset{(2.27)}{.006}\, M_1 \\
& + \underset{(8.88)}{.023}\, M_2 + \underset{(5.58)}{.114}(JV3\text{-}ENG)_{it} + \underset{(.34)}{.001}(JV4\text{-}ENG)_{it} \\
& - \underset{(-4.16)}{.017}(JV3\text{-}NONENG)_{it} + \underset{(6.87)}{.009}(JV4\text{-}NONENG)_{it},
\end{aligned}$$

$R^2 = .7643$, $F_{8,156} = 63.25$.

From equation (8.10) the only substitution effect occurs for parents horizontal in nonengineering industries. The composition of this group includes all the resource related industries, chemicals industries, and consumer related groups such as foods and textiles. Complementarity occurs when parents are horizontal in the engineering group and for parents not horizontal in nonengineering.

For mean size of impact the values are .007 for JV3-ENG, .005 for JV4-ENG, and -.003 for JV3-NONENG. Thus, the complementarity effect appears stronger than the substitution effect where it occurs.

8.4.4 <u>Parent-parent Horizointality Indexes - Beginning Date Measures</u>

The parent-parent horizontality beginning date indexes were much more sensitive to specification than the cumulative measures. The greater robustness of the cumulative measures indicates that the cumulative measures better represent the influence of JV activity. The same interpretation as was obtained with the technological split emerges: it is past JVs that influence current R&D intensity, and presumably past successes in JVs.

The best specification without the JV slope shifts is:

$$(8.11)\quad (RD/S)_{it} = \underset{(-2.03)}{-.005} + \underset{(9.43)}{.131}\, RR_{i,t-1} + \underset{(.25)}{.002}\, JS3_{it} - \underset{(-.34)}{.002}\, JS4_{it}$$

$$+ \underset{(2.97)}{.0001}\, CONC_{it} + \underset{(.80)}{.00002}\, COV_{it} - \underset{(-1.53)}{.002}\, M_1 + \underset{(5.84)}{.008}\, M_2$$

R^2 = .8330, $F_{7,157}$ = 111.89.

Since neither JS3 nor JS4 are significant, we can conclude that current JVs have little or no impact on R&D intensity when measured according to horizontality. This, however, is subject to one qualification: equation (8.11) represents the restricted form of the model by not allowing the JV effect to vary across industry groups. When the model is estimated in unrestricted form, we do find complementarity effects from current JVs in the engineering group, whether

parents are horizontal or not. Furthermore, the F test between equations 8.11 and 8.12 (F=3.67, significant at the .01 level) indicates that the unrestricted model is superior. That result is:

$$(8.12)\ (RD/S)_{it} = -.002 + .117\ RR_{i,t-1} + 7.7E\text{-}5\ CONC_{it} - 2.0E\text{-}6\ COV_{it}$$
$$(-.57)\quad (8.46)\quad (1.54)\quad (-.09)$$
$$-.002\ M_1 + .009\ M_2 + .069(JS3\text{-}ENG)_{it} + .041(JS4\text{-}ENG)_{it}$$
$$(-1.16)\quad (6.72)\quad (1.65)\quad (2.85)$$
$$+ .0003(JS3\text{-}NONENG)_{it} - .009(JS4\text{-}NONENG)_{it},$$
$$(.04)\quad (-1.38)$$
$$R^2 = .8483,\ F_{9,155} = 96.34.$$

This contrasts with the cumulative measures. There we found an insignificant effect from parents nonhorizontal in engineering. This potentially may reflect rapid changes in technology which occur in at least some of these industries. For example, rapid technological change is observable in the computers and electronic components industries, which are classified in the engineering group. When technology is rapidly changing, one can expect less of a lag in the impact from JVs. It becomes more important for firms to know of recent developments to stay competitive. Table 3.4 indicates that technologically oriented JVs far exceed nontechnologically oriented ones for this group, which lends additional credence to this argument.

8.4.5 Parent-child Horizontality Indexes - Cumulative Measures

The best specification, in restricted form, using the parent-child horizontal, cumulative indexes is:

$$(8.13)\quad (RD/S)_{it} = -.003 + .237\ RR_{i,t-1} - .0005\ JV5_{it} - .00007\ JV6_{it}$$
$$(-.93)\quad (16.58)\qquad (-.08)\qquad (-.02)$$
$$- .001\ CONC_{it} - .002\ M_1 + .020\ M_2,$$
$$(-1.44)\qquad (-.73)\qquad (7.38)$$
$$R^2 = .7815,\ F_{6,180} = 107.33.$$

The insignificance of JV5 and JV6 is representative of all restricted model specifications. Significance occurs using JV5 and JV6 when the restriction is removed and JV5 and JV6 are allowed to vary by industry groups. The following equation appears to be the best specification according to the F test (F=3.09, significant at the .05 level):

$$(8.14)\quad (RD/S)_{it} = -.006 + .251\ RR_{i,t-1} - 6.7E\text{-}5\ CONC_{it} + .001\ M_1$$
$$(-1.44)\ (17.39)\qquad (-.87)\qquad (.46)$$
$$+ .018\ M_2 - .057(JV5\text{-}EXPL)_{it} + .001(JV6\text{-}EXPL)_{it}$$
$$(6.75)\qquad (-2.98)\qquad (2.03)$$
$$+ .013(JV5\text{-}NONEXPL)_{it} - .007(JV6\text{-}NONEXPL)_{it},$$
$$(1.77)\qquad (-1.86)$$
$$R^2 = .7965,\ F_{8,178} = 87.10.$$

From equation (8.14) above, nonhorizontal JVs in resource based industries, JV6-EXPL, and horizontal JVs in nonresource based

industries, JV5-NONEXPL, have positive impacts on RD/S, indicating complementarity. Therefore, these results suggest that resource based firms entering other industries via JV tend to increase their proportion of resources devoted to R&D.

An example of this effect is a petroleum firm conducting research in petrochemicals. The parent would be in Petroleum Refining and the child would be in Basic Chemicals. The JV would most likely be a joint production and marketing arrangement with a firm in Basic Chemicals.

The other side of this example, the Chemical firm, would be represented by JV5-NONEXPL, also with a positive effect. This suggests that the petroleum firms' research causes increased research efforts in both the Petroleums and the Chemicals industries. Or, in general, research performed in resource related industries that is applicable to nonresource industries stimulates research in both.

The other two JV impacts on RD/S from equation (8.14) are negative, significant. Parent-child horizontal JVs in resource based industries and parent-child not horizontal JVs in nonresource industries cause a decreased proportion of funds allocated to R&D.

JV5-EXPL may, for example, represent an oil firm drilling for oil or a minerals firm conducting a joint mining operation. The previous argument proposed for the negativity of JV2-EXPL should apply.

JV6-NONEXPL represents nonresource firms entering into a JV in another industry. The negativity of JV6-NONEXPL suggests these firms substitute JV for R&D.

8.4.6 Parent-child Horizontality Indexes - Beginning Date Measures

The impact when JS5 and JS6 are employed appears negligible. Only in the most basic formulation is there any significant impact from JS5 or JS6. The specification F tests indicate the following equation as superior to all others:

$$(8.15)\quad (RD/S)_{it} = -.006 + .259\ RR_{i,t-1} - .032\ JS5_{it} + .005\ JS6_{it}$$
$$(-1.74)(20.88) \qquad (-1.41) \qquad (.05)$$
$$+ .0003\ COV_{it} - .001\ M_1 + .007\ M_2,$$
$$(.84) \qquad (-.55) \qquad (3.71)$$

$R^2 = .8024$, $F_{6,180} = 121.89$.

Using the beginning date measures, JS5 and JS6, there appears to be no immediate impact on RD/S.

8.5 Summary of JV's Impact on RD/S

Thus far, JV impacts on RD/S have been treated essentially in isolation. There are some broad conclusions that emerge, however, when the technological and horizontal tests are considered together. Table 8.6 presents a summary of sign and significance from the unrestricted models of RD/S determination, except for cases where the restricted model specification is indicated.

Table 8.6

Summary of Sign and Significance of RD/S Tests Using the Unrestricted Model

(a)

	JV1	JV2	JV3	JV4	JV5	JV6
EXPL	>0,*	<0,*	N/A	N/A	<0,*	>0,*
NONEXPL	>0,*	<0,*	N/A	N/A	>0,*	<0,*
ENG			>0,*	>0,NS		
NONENG			<0,*	>0,*		

(b)

	JS1	JS2	JS3	JS4	JS5	JS6
OVERALL	>0,NS	>0,NS			<0,NS	>0,NS
ENG			>0,*	>0,*		
NONENG			>0,NS	<0,NS		

Note: A * represents significance at the .05 level or better; NS represents not significant at the .05 level; and, N/A means not applicable.

In the first, place, the cumulative indexes tend to show greater significance than the beginning date indexes.[11] We infer from the superior performance of the cumulative measures that past JVs, in general, have more impact on current R&D intensity than do current JVs. This, in turn, implies that a lagged specification of JV is generally more appropriate. The one exception to this appears to occur in the engineering group where rapid technological change may make the influence of current JVs stronger.

In the cumulative indexes we also find significant variation in impact by industry group. The appropriate industry group varies, however, depending on the JV measures chosen. For the technological indexes and parent-child horizontality indexes, resource base of the industry, M_1, tends to cause differential impacts. For parent-parent horizontality, engineering base of industry, M_2, tends to cause differential impacts.

The results broadly indicate that JV activity tends to have a positive significant influence on RD/S (complementarity) for technologically oriented JVs, regardless of industry, parents horizontally related in engineering, parents not horizontally related in nonengineering, parent-child horizontal in resource industries, and parent-child not horizontal in nonresource industries.

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11 Sometimes, however, the R^2 values were higher for the model using single year intensity measures.

Substitution is indicated for nontechnological JVs, parents horizontal in nonengineering, parent-child horizontal in resource industries, and parent-child not horizoital in nonresource industries.

Table 3.4 indicates where the largest number of JVs occur. When we coupled the data in that table with the above results on complementarity and substitution, we find that complementarity tends to dominate since the largest number of JVs occur where complementarity is indicated. Thus, the overall impact appears to stimulate rather than reduce R&D. This same result emerges when the mean impact of JV is considered. One exception to this does occur for JV2 in the resources group. JV2-EXPL produces the largest effect, -.023, when evaluated at the mean. Table 3.4 further shows that JV2 is more predominant than JV1 in these industries, of which mining and exploration ventures constitute a portion. The substitution effect suggests that these firms focus more attention on acquisition and usage of resources than on technological development and that they may be willing to reduce their commitments to technology development when it competes with resource acquisition.

The consistency with which M_1 enters as negative, significant in the RD/S model indicates that resource based firms, in general, devote less to technological development than do nonresource industries. It is thus not surprising to find JVs substituting for RD/S in this group.

CHAPTER 9

SUMMARY AND CONCLUSIONS

This study has considered the causes and effects of JV activity. Within such a broad title no study could be expected to cover all potential issues, nor does the current study purport to do so. Thus, several limitations in the scope of the current study need to be recognized.

The following limitations in scope are considered to be of primary importance to interpretations of the analysis. First, the entire range of JV activity was not covered in this analysis. Issues relating to international JVs and JVs between nonmanufacturing firms were not treated. The study focused solely on domestic JVs in manufacturing and mining. Even within manufacturing and mining industries, the cross-firm analysis falls far short in coverage, with only a limited set of industries analyzed. This latter limitation was generally caused by insufficient JV observations within those industries not covered.

Besides not covering the full range of JV activity, analysis of the impacts of JV activity on firms' decision variables was limited. In sections on the effects from JV activity analysis was restricted to the effects on R&D and profitability. Other decision variables such as firms' investment activity or advertising may well be affected by JV activity. It is also possible, as suggested in

Chapter 4, that risk and managerial risk aversion may play an important role in the decision to form a JV. This issue was inadequately treated in the analysis of causes, as well as in the analysis of effects.

Finally, the interrelationship between mergers and JVs is certainly an important issue that was briefly touched on, but by and large neglected.

The remainder of the chapter presents a summary of results and suggestions for future work.

9.1 Summary of Results

Having pointed out what the study does not do, what it did do is summarized in this section. Several issues were addressed in the previous chapters, with several results obtained. This summary will focus on those issues and results that are considered to be of major importance to the study of JV behavior. As a matter of convenience, the summary is divided into two parts: (1) the causes of JV activity, and (2) the effects from JV activity.

9.1.1 Summary of the Causes of JV Activity

Chapters 4 and 5 treated the causes of JV activity: Chapter 4 dealt with theoretical considerations, while Chapter 5 dealt with empirical examination. As discussed in Chapter 4, subsequent examination in Chapter 5 focused only on large firms, since small firm data were typically unavailable. Recognition of this large firm focus is important because a large number of JVs involved large-small pairings. Such large-small pairings suggests that whatever interpre-

tations emerge only apply to large firms and any effort to extrapolate such results to small firm JV behavior would likely be erroneous. Further, such large-small pairings suggest that large firm analysis should focus on expected input contributions by large firms, whereas input contribution by small firms should remain largely undetected. Chapter 4 provided rationales for such large-small pairings.

In Chapter 5, the empirical analysis examined both cross-firm and cross-industry tests of the causes of JV activity. For the cross-firm tests, which employed a probit model, the following principal result emerged:

Result 1: The probabilty that a large firm will engage in a JV increase with:

1) the large firm's size in all industries examined, perhaps reflecting large firms' preexisting market shares and distribution channels (equations 1 to 4 in Table 5.2),
2) lower liquidity and higher leverage in Chemicals and Engineering based industries, but not Resource based industries, possibly reflecting financial weakness, and/or possibly reflecting financial aggressiveness in the sense of lower managerial risk aversion (equations 1 to 3 in Table 5.2), and
3) faster capital expansion in Chemicals, but not in Engineering or Resource based industries (equations 1 to 3 in Table 5.2).

The results from these cross-firm tests appeared to produce best results in Chemicals, and to a lesser extent in the Engineering group. This contrast with the Resource group suggests that mis-specification errors are likely greater for the Resource group. Also note that the significance of the capital growth variable in Chemicals is consistent with lower liquidity and higher leverage resulting from aggressive expansion strategies.

When cross-industry tests of the causes of JV activity were considered the following results regarding industry characteristics that appear conducive to JV activity emerged:

Result 2: Technologically oriented JVs are stimulated (in the sense that JV activity increases) by a combination of scale factors (perhaps barriers to entry) and high industry average R&D intensity (perhaps reflecting significant technological oportunities or nonprice rivalry). Further contributing factors may be rapid capital growth and lower industry average profitability (equations 1 and 3 in Table 5.3).

Result 3: Nontechnologically oriented JVs are stimulated by scale factors and rapid capital growth. Higher R&D intensity had a negative impact on the level of nontechnological JV activity but an insignificant impact on intensity. Lower industry average profitability was not important for the level of nontechnological JV activity, but did affect intensity (equations 2 and 4 in Table 5.3).

9.1.2 Summary of the Effects of JV Activity

Results on the effects from JV activity were obtained from cross-firm and cross-industry analysis. Analysis was restricted to the effects from JV on R&D and profitability.

Principal cross-firm results are as follows:

Result 4: JVs substitute for R&D at the firm level in Chemicals and Engineering industry groups, but not in Resource based industries (equations 1 to 3 in Table 6.4).

Result 5: The long run R&D substitution effect is stronger than the short run subsitution effect (principally equations 1 and 3 in Table 6.6 in comparison to equations 1 and 3 in Table 6.4).

Result 6: JVs tend to have a negative, significant impact on large firms' rate of return in Chemicals and

Engineering industry groups (equations 1 and 3 in Table 6.9).

Result 7: The long run effect on rate of return is insignificant. Thus, the cost of external knowledge acquisition via JV (i.e., sacrificed rate of return relative to that obtained through internal development) appeared to be recovered as time passes (principally equations 1 and 3 in Table 6.11 in comparison to equations 1 and 3 in Table 6.9).

Above results 4 through 7 present a consistent picture of JVs effect on R&D. In particular, result 7 is the only reasonable result in light of result 5. If long run profitability were adversely affected by following a JV strategy, firms might be expected to attempt a shift back to internal R&D, since deficiencies in R&D staffs could be overcome in the long run. On the other hand, if firms observe that long run profitability is not adversely affected by substituting JV for internal R&D, then their tendencies to engage in such substitutions would be reinforced.[1]

In the cross-industry analysis of the effects from JV activity the examination employed measures of industry level JV activity divided according to purpose (technological orientation versus non-technological orientation) and horizontality (parent-parent horizontal versus parent-parent nonhorizontal and parent-child

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[1] Such a statement assumes managerial objectives based on stockholder wealth maximization. If managers maximize say earnings per share, then short run effects would be of paramount importance, while longer run effects would have a decidedly inferior position in the decision making process.

horizontal versus parent-child nonhorizontal). In tests of JVs' effect on rate of return, only horizontality measures were employed since Berg and Friedman [10] had previously analyzed the effects on rate of return for the technological-nontechnological division of JV activity. The R&D tests, however, employ all those sets of classifications.

The cross-industry results are as follows:

Result 8: Indexes based on both parent-parent and parent-child nonhorizontal relationships produced a negative, significant impact on industry average rates of return. Such evidence is consistent with the acquisition of technological or commercial know-how via JV, since such combinations may reduce risks, reduce time-lags, or serve other functional purposes. The result is also consistent with new market entry activity (see Tables 7.1 and 7.5).

Result 9: Parent-parent horizontal indexes produced a positive, significant impact on industry average rates of return. This relationship appeared weak, in that it was sensitive to model specification and represents proportionately fewer JVs than are represented in the nonhorizontal indexes. Such evidence does, however, suggest a weak potential for collusive behavior when parent-parent horizontal JVs occur (see Tables 7.1 and 7.5).

Result 10: Major segments of JV activity showed positive, significant effects on both the level and intensity of R&D expenditures. This effect appeared strongest for the broad classification - technologically oriented JVs and nonhorizontal JVs. Industry grouping (i.e., Resource, Technology, and Engineering base of an industry), however, caused some variation in results. These results are interpreted as indicating that JV and R&D are complements at the industry level. Further, such complementarity may stem from induced R&D rivalry through JVs (see especially, equations 8.6 through 8.15 in Chapter 8).

Result 11: Difference in significance occur in equations using cumulative indexes and beginning date indexes.

> Cumulative indexes tended to outperform the beginning date indexes. Since cumulative indexes reflect past, as well current JV activity, it is inferred that past successes in JVs may cause the complementarity effect. That is, a lag effect running from JV to R&D appears to exist (see, for example, Table 8.1 and 8.2).

9.2 Suggestions for Future Work

The current work illustrates those issues regarding JVs which are both important and interesting and thus merit further analysis. This section provides some opinions about the direction future work might take. The following discussion deals with two main areas where improvements or extensions are expected to have greatest impact: (1) overcoming existing limitations in scope and data availability and (2) improving model specification.

Overcoming existing limitations in scope and data availability. As a starting point, future analysis could be directed towards augmenting the scope of the current analysis in those areas mentioned at the beginning of the chapter. For example, analysis covering international JVs, nonmanufacturing JVs, and industries which were not covered in the manufacturing and mining sectors might produce interesting results. Perhaps of even greater importance would be the development of models which integrate JVs and mergers. It is expected that JVs and mergers provide substitute methods of acquiring external knowledge, though probably not perfect substitutes.

Data availability has placed restrictions on the current study. First, the absence of small firm data has restricted analysis to

large firms. Analysis of small firms which engage in JVs could offer considerable substantiation to the current large firm results. Second, the absence of cost and revenue data for most JVs restricted the cross-firm analysis in the sense that models employing dichotomous variables had to be used. Since JVs with cost data varied considerably in resources devoted to the JV, it is unlikely that they have as uniform an impact on firms as is implied by the current use of dichotomous variables. Cost and revenue data, for example, would allow analysis which recognizes impacts by size of the JV. Unfortunately, such cost and revenue data are not available from public sources, so we must look to regulatory agencies for required disclosure. Third, the absence of termination dates affected the cross-pool industry models employing the cumulative indexes. By incorporating termination dates in the cumulative indexes, a better representation of on-going JVs could be accomplished. Inference regarding the lag effect, captured in the cumulative indexes, should be more exact.

Improving model specification. This part of the discussion will consider potential specification errors as induced by the form of the model and by omitted variables. For form of the model, two considerations seem relevant: simultaneous equations versus single equations and lag structure.

In general, one has to suspect that any equation is part of a system of equations, unless there is some basis for specifying a recursive system. Thus, one must suspect that a potential for

simultaneity bias exists in the current work. The suggestion, then, is that both cross-firm and cross-industry models be estimated using a simultaneous equation approach. Further, this observation suggests that current models are likely to be underspecified since rank conditions would not always be satisfied.

Next, the analysis has addressed the issue of lag structure with respect to some variable in almost all models (e.g., lag effect of JV on R&D and rate of return, lag effect of rate of return on R&D, and lag effect of R&D on rate of return). Insufficient time series observations has often forced some assumption about the form of the lag structure, such as a simple one period lag in several models. Given that time has passed beyond the period covered in this study, more observations should now be available through the inclusion of later years. Thus, better estimates of lag structures could be obtained. Also, the cross-pool models' autocorrelation estimates could be improved.

Next, turning to omitted varaibles, the strongest need seems to exist for the inclusion of risk proxies. First, in Chapter 5's cross-firm model of the causes of JV activity, managerial risk aversion was suggested as a possible discriminating influence on firms' decisions to engage in JVs. Second, Chapter 7's cross-industry rate of return models might well be improved if industry risk proxies are included. Under the current specification, the variables included may be functioning as industry risk proxies (e.g, the RD/S variable may capture the risk of technological obsolescence).

The explicit introduction of a general industry risk measure could make the interpretation of other variables clearer. Risk proxies might also be included in Chapter 8's R&D level and R&D intensity models. One would expect, for example, that the average R&D expenditures of an industry may be higher the greater the industry's risk.

To include such risk proxies, one alternative is to employ Beta from the Capital Asset Pricing Model (CAPM).[2] This could be accomplished by introducing individual firm's betas in cross-firm analysis[3] and industry betas in cross-industry analysis.

The inclusion of risk proxies tends to be a fairly general suggestion applying to all models. Remaining suggestions for

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2 This approach was initially considered, but discarded as theoretically inconsistent. CAPM as developed by Sharpe [56], Lintner [35], Mossin [43], among others specifies an equilibrium relationship between expected rate of return and risk, measured by Beta. Beta in that model captures all relevant risk (e.g., technological risk, marketing risk, etc.), with other effects such as JVs or R&D intensity cancelling out in the error term, except for that portion captured in Beta. Thus, CAPM in its single factor form leaves no room for other model variables. Further, current models have employed rate of return on assets and the connection between that measure and stock market rate of return is not clear. These considerations, plus others that arise in the context of using Beta as a risk measure, discouraged its use. More recent developments in Capital Market Theory, however, allow the specification of a multi-factor CAPM, which may provide a stronger theoretical basis for the inclusion of Beta along with other variables. See, for example, Ross [50].

3 It seems reasonable to interpret Beta as a generalized measure of managerial risk aversion in the cross-firm model of the causes of JV activity. Higher betas should be associated with less risk aversion, since alternative strategies, generating lower betas, can be assumed to be available to the firm.

additional variables tend to be more model specific and more reasonable to deal with on a chapter-by-chapter basis.

Chapter 5's model of the cross-firm causes of JV activity was one of the most difficult areas in terms of specification and the model most likely to suffer from underspecification. Some additional variables that might improve the model are firms' market share and advertising and measures of organizational structure. Market share and advertising would seem to be better proxies for a large firm's strength in marketing and distribution channels than firm size. They would seem to approximate that dimension of the large firm's inputs into a JV more directly. Organizational structure variables could be used to test for an effect from internal resistance to external knowledge acquisition. For example, Hlavacek, Dovey, and Biondo [27] suggest that a large firm's R&D manager may view a JV as undesirable, perhaps even a threat to his position, while a division manager may not. Thus, variables representing where the decision to engage in a JV is made within the firm might improve model specification.[4]

In both Chapters 5 and 6, the cross-firm models used for the three industry groups seem to perform more poorly for the Resource based industries than for Chemicals and Engineering based industries. It is suggested, then, that additional or alternative variables be

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[4] Armour and Teece [2] examine the effects of organizational structure on economic performance in Petroleums. Organizational structure variables similar to the ones they employ certainly represent a possible candidate. Their organizational structure variables classify firms by location of responsibility within the firm for operating and strategic decision making.

added to the models for the Resource based industries. Some possible improvements in model specification for those industries might be accomplished through including variables which reflect resource acquisition and fabrication. For example, exploration budgets for oil firms may be an important determinant of interfirm differences. Further, inclusion of risk proxies may significantly affect results in Resource based industries.

Finally, in Chapter 8, the RD/S cross-pool models were estimated using three separate classifications of JV activity by purpose and horizontality. Interpretations from the separate models were difficult. If interaction effects had been included, clearer interpretations could have been made. It is suggested that future analysis incorporate interaction effects by creating 4-way or 6-way splits of JV activity, rather than the 3 2-way splits employed. For example, an index based on technological orientation and parent-parent horizontal could be formed. To accomplish this, however, would require a longer time series than that employed. Also, the issue of vertical relationships in the cross-pooled models might provide interesting results. Thus, the present study reveals a number of avenues for additional research.

APPENDIX

In Chapter 3, patterns of JV behavior and the construction of industry indexes of JV activity were discussed. The tables in that chapter were summary tables. The tables presented in this appendix provide more detail and illustrate some of the methodology and problems that arose in analysis.

Table A.1 shows the effect of relying on Compustat as the primary parent firm information source. Column 4 represents the number of firms from the JVAP data base engaging in JVs for selected 2-digit industries (column 2), while column 5 shows the number of firms which appear in Compustat and column 7 shows the percent of Compustat representation. The average representation in Compustat is 61.8%. Column 5 also indicates the maximum possible number of useable JV observations in cross-firm analysis, though missing R&D data often reduced the useable set below those maximums.

The next four tables present data relevant to the cross-industry models in Chapters 5, 7, and 8. The first of these tables, Table A.2, presents the approximately 2 1/2-digit industry groups used in the cross-industry analysis and also used to define horizontality. The table also illustrates some of the problems in using SIC codes to define industry groups by showing the corresponding 3-digit codes from two different sources: Compustat and the Securities and Exchange Commission (SEC). Note, for example, the difference in 3-digit codes which occurs in Textiles and the switch in codes between Iron and Steel and Nonferrous Metals.

The remaining 3 tables present the year-by-year incidence of JV activity for the 3 classifications: technologically oriented JVs (JV1#) versus nontechnologically oriented JVs (JV2#), both of which appear in Table A.3; parent-parent horizontal JVs (JV3#) versus parent-parent nonhorizontal JVs (JV4#), both of which appear in Table A.4; and parent-child horizontal JVs (JV5#) versus parent-child nonhorizontal JVs (JV6#), both of which appear in Table A.5. These incidence measures were sometimes entered into the cross-industry models as they are represented in the tables, but sometimes they were converted to intensity measures for the analysis.

Table A.1

Number of Joint Ventures, Number of Firms Engaging in Joint Ventures, and Number of Firms Engaging in Joint Ventures Which are Listed in Compustat (1964-1973)

(1) Industry Description	(2) SIC	(3) Number of JV Partici-pations[a]	(4) Number of Firms Engaging in JVs	(5) Number of Compustat Firms Engaging in JVs	(6) Number of Firms Omitted By Using Compustat	(7) Percent Compustat Represen-tation (%)	(8) Percent Of Omitted Firms (%)
Metal Mining	10	40	19	12	7	63	37
Oil & Gas Extraction	13	28	22	14	8	64	36
Foods	20	43	36	21	15	58	42
Textile Products	22	18	17	11	6	65	35
Textile Apparel Mfg.	23	6	5	5	0	100	0
Forrest Products	24	18	12	5	7	42	58
Paper & Paper Products	26	18	12	7	5	58	42
Publishing & Printing	27	30	27	11	16	41	59
Chemicals	28	113	64	36	28	56	44
Petroleum Refining	29	104	33	27	6	82	18
Rubber & Plastic	30	14	12	6	6	50	50
Leather & Shoes	31	3	3	2	1	67	33
Cement, Clay, & Glass	32	34	21	16	5	76	24
Steel & Non-ferrous Metals	33	68	39	25	14	64	36
Metal Containers & Fabricated Metals	34	24	20	11	9	55	45
Nonelectrical Machinery	35	72	49	32	17	65	35
Electrical Machinery	36	73	53	23	30	43	57
Transportation	37	70	40	27	13	68	32
Instruments	38	33	26	10	16	38	62
Precious Metals & Leisure	39	12	11	9	2	82	18

[a] For JVs between two firms in the same industry double counting occurs in column 3.

Table A.2

Industry Groups Used in Cross-industry Analysis

Industry Description	2 1/2-digit Industry Groups	Compustat 3-digit Industries	S.E.C. 3-digit Industries
Metal Mining	10.0	100,102,103,104	101,102,103,104, 105,106,109
Oil & Gas Extraction	13.1	131	131,132
General Foods	20.1	200,201,202,203	201,202,203,207, 209
Textiles	22.1	220	221,222,223,224, 225,226,228,229
Basic Chemicals	28.1	280	281,282
Ethical Drugs	28.3	283	283
Paint, Agricultural Chemicals, N.E.C.	28.4	285,287,289	285,286,287,289
Petroleum Refining	29.0	291	291
Glass & Nonmetallic Containers	32.1	321,322,326	321,322,323,326
Cement, Clay, Gypsum, N.E.C.	32.2	324,325,327,329, 295[a]	324,325,327,329, 295[a]
Iron and Steel	33.1	331	331,332
Nonferrous Metals	33.2	332,333,334,335	333,334,335,336
Metal Containers & Fabricated Metals	34.0	342,343,344,345, 348,349	all 34's
Nonelectrical Machinery, General	35.1	351,352,353	352,353,356
Nonelectrical Machinery, Specialty	35.2	354,355,356,358	354,355,358
Electrical Machinery	36.1	360,361,363,364,369	362,363,364,369
Electronics, Communication, & Computers	36.2	362,365,366,367, 357[a]	362,365,366,367, 357[a]
Autos & Auto Parts	37.1	371,379	371,379
Aircraft & Transportation Equipment	37.2	372,373,374	372,373,374
Scientific Instruments & Measuring Devices	38.0	381,382,383,384, 386,387	381,382,383,384, 386,387

[a] These 3-digit industries are reclassified by product and process homogeneity into a 2 1/2-digit classification outside their Compustat or SEC 2-digit classification.

Table A.3

Joint Ventures by Year and Industry --
Technological-Nontechnological Classification

Industry Groups	Type[a]	64	65	66	67	68	69	70	71	72	73	74	75	Total
10.0	JV1#	1.0	2.5	1.5	1.0	1.0	0.0	1.0	2.0	2.0	1.0	0.5	0.5	14.0
	JV2#	6.0	5.5	5.5	6.0	5.0	3.0	1.0	1.0	7.0	6.0	1.5	1.5	49.0
	JVT#	7.0	8.0	7.0	7.0	6.0	3.0	2.0	3.0	9.0	7.0	2.0	2.0	63.0
13.1	JV1#	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	4.0
	JV2#	2.0	2.0	2.0	2.0	2.0	1.0	3.0	3.0	1.0	1.0	0.0	0.0	19.0
	JVT#	2.0	2.0	2.0	2.0	2.0	1.0	4.0	4.0	2.0	2.0	0.0	0.0	23.0
20.1	JV1#	1.0	1.5	1.5	1.5	2.0	1.5	1.5	1.5	0.5	0.0	0.0	0.5	13.0
	JV2#	1.0	1.5	1.5	0.5	1.0	1.5	1.5	1.5	0.5	0.0	0.0	0.5	11.0
	JVT#	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	1.0	0.0	0.0	1.0	24.0
28.1	JV1#	5.5	6.0	3.5	4.5	3.0	3.0	5.5	4.5	4.5	4.5	2.0	0.5	47.0
	JV2#	2.5	3.0	0.5	1.5	4.0	5.0	7.5	7.5	3.5	2.5	3.0	1.5	42.0
	JVT#	8.0	9.0	4.0	6.0	7.0	8.0	13.0	12.0	8.0	7.0	5.0	2.0	89.0
28.3	JV1#	1.5	2.5	1.0	1.0	1.0	1.5	2.5	1.0	0.0	0.0	0.0	0.5	12.5
	JV2#	0.5	0.5	0.0	0.0	0.0	0.5	1.5	1.0	0.0	0.0	0.0	0.5	4.5
	JVT#	2.0	3.0	1.0	1.0	1.0	2.0	4.0	2.0	0.0	0.0	0.0	1.0	17.0
28.4	JV1#	0.0	1.0	1.0	1.5	2.0	0.5	0.0	0.0	0.0	0.0	0.0	1.0	7.0
	JV2#	0.0	1.0	1.0	0.5	1.0	0.5	0.0	0.0	0.0	1.0	1.0	1.0	7.0
	JVT#	0.0	2.0	2.0	2.0	3.0	1.0	0.0	0.0	0.0	1.0	1.0	2.0	14.0
29.0	JV1#	3.5	6.0	4.5	3.0	3.5	6.5	8.0	4.5	3.5	3.0	1.5	1.0	48.5
	JV2#	1.5	19.0	13.5	8.0	7.5	8.5	10.0	8.5	10.5	10.0	2.5	1.0	110.5
	JVT#	15.0	25.0	18.0	11.0	11.0	15.0	18.0	13.0	14.0	13.0	4.0	2.0	159.0
32.1	JV1#	2.0	1.5	0.0	0.0	0.5	0.0	0.0	0.0	2.0	2.0	1.0	0.0	9.0
	JV2#	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	1.0	1.0	1.0	0.0	4.0
	JVT#	2.0	2.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0	3.0	2.0	0.0	13.0
32.2	JV1#	0.0	0.0	0.5	0.5	2.0	2.0	0.5	0.5	0.0	0.5	0.0	0.0	6.5
	JV2#	0.0	1.0	1.5	0.5	0.0	2.0	2.5	0.5	1.0	2.5	1.0	0.0	12.5
	JVT#	0.0	1.0	2.0	1.0	2.0	4.0	3.0	1.0	1.0	3.0	1.0	0.0	19.0
33.1	JV1#	0.0	0.5	0.5	0.0	1.0	1.5	0.5	0.0	0.5	0.0	0.0	0.5	5.0
	JV2#	1.0	0.5	1.5	1.0	2.0	3.5	1.5	1.0	2.5	1.0	0.0	0.5	16.0
	JVT#	1.0	1.0	2.0	1.0	3.0	5.0	2.0	1.0	3.0	1.0	0.0	1.0	21.0
33.2	JV1#	1.0	2.5	0.0	2.0	2.5	1.0	1.5	0.5	1.5	0.5	0.0	0.0	13.0
	JV2#	0.0	1.5	1.0	2.0	2.5	3.0	3.5	3.5	5.5	2.5	0.0	0.0	25.0
	JVT#	1.0	4.0	1.0	4.0	5.0	4.0	5.0	4.0	7.0	3.0	0.0	0.0	38.0

Table A.3 - continued

Industry Groups	Type[a]	64	65	66	67	68	69	70	71	72	73	74	75	Total
34.0	JV1#	0.0	0.0	1.0	1.5	0.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	7.5
	JV2#	0.0	1.0	2.0	1.5	1.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0	8.5
	JVT#	0.0	3.0	3.0	3.0	1.0	3.0	1.0	1.0	1.0	2.0	0.0	0.0	16.0
35.1	JV1#	0.5	0.5	0.0	2.0	2.0	1.0	0.0	0.5	2.5	1.5	1.0	0.5	12.0
	JV2#	0.5	0.5	0.0	0.0	0.0	1.0	1.0	0.5	1.5	0.5	1.0	0.5	7.0
	JVT#	1.0	1.0	0.0	2.0	2.0	2.0	1.0	1.0	4.0	2.0	2.0	1.0	19.0
35.2	JV1#	0.0	1.0	1.0	2.0	2.0	0.0	2.0	2.0	1.0	1.0	0.5	0.0	12.5
	JV2#	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.5	0.0	2.5
	JVT#	0.0	1.0	1.0	2.0	2.0	0.0	3.0	3.0	1.0	1.0	1.0	0.0	15.0
36.1	JV1#	2.0	4.0	2.5	2.0	2.5	0.0	0.5	0.5	2.0	0.5	1.0	1.0	18.5
	JV2#	1.0	1.0	0.5	0.0	0.5	0.0	0.5	1.5	1.0	0.5	0.0	0.0	6.5
	JVT#	3.0	5.0	3.0	2.0	3.0	0.0	1.0	2.0	3.0	1.0	1.0	1.0	25.0
36.2	JV1#	0.0	3.0	5.0	2.0	1.0	3.5	4.5	0.0	5.0	4.0	3.5	3.5	35.0
	JV2#	0.0	1.0	2.0	0.0	0.0	1.5	2.5	0.0	3.0	1.0	0.5	1.5	13.0
	JVT#	0.0	4.0	7.0	2.0	1.0	5.0	7.0	0.0	8.0	5.0	4.0	5.0	48.0
37.1	JV1#	2.0	3.5	1.5	2.5	3.0	2.5	4.0	6.0	4.0	1.0	0.5	0.0	30.5
	JV2#	0.0	0.5	0.5	0.5	1.0	1.5	1.0	1.0	2.0	0.0	0.5	0.0	8.5
	JVT#	2.0	4.0	2.0	3.0	4.0	4.0	5.0	7.0	6.0	1.0	1.0	0.0	39.0
37.2	JV1#	1.0	1.0	1.0	0.5	4.5	5.5	3.5	1.5	2.5	1.0	0.5	0.0	22.5
	JV2#	0.0	0.0	1.0	0.5	1.5	1.5	1.5	0.5	1.5	0.0	0.5	0.0	8.5
	JVT#	1.0	1.0	2.0	1.0	6.0	7.0	5.0	2.0	4.0	1.0	1.0	0.0	31.0
38.0	JV1#	0.5	2.0	1.0	2.5	3.0	2.0	2.0	1.0	0.0	0.0	1.0	2.5	17.5
	JV2#	0.5	1.0	0.0	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.5
	JVT#	1.0	3.0	1.0	3.0	4.0	2.0	2.0	1.0	0.0	0.0	1.0	3.0	21.0

[a] JVT# = JV1# + JV2#.

Table A.4

Joint Ventures by Year and Industry --
Parent-parent Horizontality Classification

Industry Groups	Type[a]	64	65	66	67	68	69	70	71	72	73	74	75	Total
10.0	JV3#	2	3	4	4	4	0	0	0	4	4	0	0	25
	JV4#	2	5	2	3	4	3	2	1	3	4	3	3	35
	JVTH#	4	8	6	7	8	3	2	1	7	8	3	3	60
13.1	JV3#	1	1	0	0	0	0	2	2	0	0	0	0	6
	JV4#	0	0	2	3	1	1	1	0	1	2	1	0	12
	JVTH#	1	1	2	3	1	1	3	2	1	2	1	0	18
20.1	JV3#	0	1	1	0	0	0	1	1	0	0	1	1	6
	JV4#	1	1	1	2	1	3	0	1	1	0	0	0	11
	JVTH#	1	2	2	2	1	3	1	2	1	0	1	1	17
28.1	JV3#	0	1	1	1	1	2	1	0	3	3	0	0	13
	JV4#	4	7	3	2	5	4	9	6	7	4	3	2	56
	JVTH#	4	8	4	3	6	6	10	6	10	7	3	2	69
28.3	JV3#	0	0	0	0	0	0	2	2	0	0	0	0	4
	JV4#	1	3	1	1	1	2	2	2	0	0	0	1	12
	JVTH#	1	3	1	1	1	2	4	2	0	0	0	1	16
28.4	JV3#	0	0	0	0	0	0	0	0	0	1	2	1	4
	JV4#	0	0	1	1	2	1	1	0	0	0	0	1	7
	JVTH#	0	0	1	1	2	1	1	0	0	1	2	2	11
29.0	JV3#	8	14	6	1	1	6	8	3	9	8	0	0	64
	JV4#	2	5	10	8	8	6	8	6	3	3	4	2	65
	JVTH#	10	19	16	9	9	12	16	9	12	11	4	2	129
32.1	JV3#	0	0	0	0	0	0	0	0	0	0	0	0	0
	JV4#	2	2	0	0	1	0	0	0	3	3	2	0	13
	JVTH#	2	2	0	0	1	0	0	0	3	3	2	0	13
32.2	JV3#	0	0	0	0	0	0	0	0	1	1	0	0	2
	JV4#	0	0	0	2	2	2	0	3	2	1	0	1	13
	JVTH#	0	0	0	2	2	2	0	3	3	2	0	1	15
33.1	JV3#	0	0	0	0	0	0	0	2	2	0	0	0	4
	JV4#	0	2	1	0	3	5	2	1	0	1	1	1	17
	JVTH#	0	2	1	0	3	5	2	3	2	1	1	1	21
33.2	JV3#	1	1	1	1	0	0	0	0	0	0	0	0	4
	JV4#	1	3	1	2	3	1	4	4	4	3	1	0	27
	JVTH#	2	4	2	3	3	1	4	4	4	3	1	0	31

Table A.4 - continued

Industry Groups	Type[a]	64	65	66	67	68	69	70	71	72	73	74	75	Total
34.0	JV3#	0	0	0	0	0	0	0	0	0	0	0	0	0
	JV4#	0	1	2	2	3	2	2	1	1	2	3	1	20
	JVTH#	0	1	2	2	3	2	2	1	1	2	3	1	20
35.1	JV3#	1	1	0	0	1	1	0	0	0	0	0	0	4
	JV4#	0	0	0	2	2	1	2	3	5	5	3	3	26
	JVTH#	1	1	0	2	3	2	2	3	5	5	3	3	30
35.2	JV3#	0	0	0	0	0	0	0	0	0	0	0	0	0
	JV4#	0	0	0	2	2	0	4	5	3	2	2	2	22
	JVTH#	0	0	0	2	2	0	4	5	3	2	2	2	22
36.1	JV3#	1	2	1	0	0	0	0	0	0	0	0	0	4
	JV4#	3	5	3	2	2	1	1	2	5	3	2	1	30
	JVTH#	4	7	4	2	2	1	1	2	5	3	2	1	34
36.2	JV3#	2	4	2	0	1	1	0	2	4	2	3	3	24
	JV4#	0	1	5	5	1	4	9	6	5	6	2	4	48
	JVTH#	2	5	7	5	2	5	9	8	9	8	5	7	72
37.1	JV3#	2	2	0	1	3	2	0	1	1	0	0	0	12
	JV4#	0	2	3	4	3	2	4	7	5	4	0	0	34
	JVTH#	2	4	3	5	6	4	4	8	6	4	0	0	46
37.2	JV3#	0	0	0	0	0	0	1	1	0	0	0	0	2
	JV4#	1	1	2	3	5	5	4	3	4	4	0	1	33
	JVTH#	1	1	2	3	5	5	5	4	4	4	0	1	35
38.0	JV3#	0	0	0	0	0	0	0	0	0	0	0	0	0
	JV4#	0	0	1	0	2	0	2	1	1	0	0	3	10
	JVTH#	0	0	1	0	2	0	2	1	1	0	0	3	10

[a] JVTH#=JV3# + JV4#.

Note: SIC's 32.1, 34.0, 35.2, and 38.0 were omitted from cross-industry analysis since their JV3# vector equals zero.

Table A.5

Joint Ventures by Year and Industry --
Parent-child Horizontality Classification

Industry Groups	Type[a]	64	65	66	67	68	69	70	71	72	73	74	75	Total
10.0	JV5#	0	1	4	6	5	2	1	0	1	1	0	0	21
	JV6#	1	2	2	1	1	0	1	2	1	0	1	1	14
	JVTC#	1	3	6	7	6	2	2	2	2	1	1	1	35
13.1	JV5#	1	1	0	1	1	0	2	2	1	1	0	0	10
	JV6#	0	0	1	1	0	1	1	0	0	0	0	0	4
	JVTC#	1	1	1	2	1	1	3	2	1	1	0	0	14
20.1	JV5#	0	0	0	0	0	0	1	1	0	0	0	0	2
	JV6#	0	1	2	2	1	3	1	1	1	0	0	1	13
	JVTC#	0	1	2	2	1	3	2	2	1	0	0	1	15
28.1	JV5#	3	5	1	1	2	3	3	1	0	0	0	0	19
	JV6#	0	3	3	3	4	4	9	6	6	6	3	2	49
	JVTC#	3	8	4	4	6	7	12	7	6	6	3	2	68
28.3	JV5#	0	0	0	1	1	0	0	0	0	0	0	0	2
	JV6#	0	2	1	0	0	2	2	2	0	0	0	1	10
	JVTC#	0	2	1	1	1	2	2	2	0	0	0	1	12
28.4	JV5#	0	0	0	1	1	1	1	0	0	0	0	0	4
	JV6#	0	0	2	1	1	1	0	0	0	0	0	2	7
	JVTC#	0	0	2	2	2	2	1	0	0	0	0	2	11
29.0	JV5#	0	0	0	0	2	2	0	0	1	1	0	0	6
	JV6#	0	10	16	9	9	6	12	6	2	7	7	2	86
	JVTC#	0	10	16	9	11	8	12	6	3	8	7	2	92
32.1	JV5#	0	0	0	0	0	0	0	0	0	1	1	0	2
	JV6#	1	2	0	0	1	0	0	0	2	3	1	0	10
	JVTC#	1	2	0	0	1	0	0	0	2	4	2	0	12
32.2	JV5#	0	0	1	1	0	0	0	0	1	0	0	0	3
	JV6#	0	0	1	1	2	2	2	3	2	2	2	1	18
	JVTC#	0	0	2	2	2	2	2	3	3	2	2	1	21
33.1	JV5#	0	0	0	0	1	2	1	0	0	0	1	1	6
	JV6#	0	0	1	1	3	3	2	1	2	2	1	0	16
	JVTC#	0	0	1	1	4	5	3	1	2	2	2	1	22
33.2	JV5#	1	1	1	1	0	0	0	0	1	1	0	0	6
	JV6#	1	2	0	2	4	3	6	4	1	1	0	0	24
	JVTC#	2	3	1	3	4	3	6	4	2	2	0	0	30

Table A.5 - continued

Industry Groups	Type[a]	64	65	66	67	68	69	70	71	72	73	74	75	Total
34.0	JV5#	0	0	0	0	0	0	0	0	0	0	0	0	0
	JV6#	0	1	2	3	1	2	2	0	0	1	0	0	12
	JVTC#	0	1	2	3	1	2	2	0	0	1	0	0	12
35.1	JV5#	0	0	0	0	1	1	0	0	0	1	1	0	4
	JV6#	0	1	0	2	2	1	2	2	0	1	1	1	13
	JVC#	0	1	0	2	3	2	2	2	0	2	2	1	17
35.2	JV5#	0	0	0	0	0	0	0	0	0	0	0	0	0
	JV6#	0	0	0	2	2	0	4	3	1	1	1	0	14
	JVC#	0	0	0	2	2	0	4	3	1	1	1	0	14
36.1	JV5#	1	1	0	0	0	1	1	0	0	0	1	0	5
	JV6#	1	4	3	2	3	0	0	2	2	0	1	1	19
	JVC#	2	5	3	2	3	1	1	2	2	0	2	1	24
36.2	JV5#	0	3	4	1	1	4	3	2	4	2	4	4	32
	JV6#	0	2	3	1	1	2	4	1	1	0	0	2	17
	JVC#	0	5	7	2	2	6	7	3	5	2	4	6	49
37.1	JV5#	0	0	0	1	3	3	1	0	0	0	0	0	18
	JV6#	1	2	1	2	3	1	5	7	4	1	0	0	27
	JVC#	1	2	1	3	6	4	6	7	4	1	0	0	35
37.2	JV5#	0	0	0	0	2	2	0	0	0	0	0	0	4
	JV6#	0	0	2	1	5	5	4	2	2	2	0	1	24
	JVC#	0	0	2	1	7	7	4	2	2	2	0	1	28
38.0	JV5#	0	0	0	0	0	0	0	0	0	0	0	1	1
	JV6#	0	1	1	2	2	2	2	2	1	0	1	2	16
	JVC#	0	1	1	2	2	2	2	2	1	0	1	3	17

[a] JVTC#=JV5# + JV6#.

Note: SIC's 34.0 and 35.2 were omitted from cross-industry analysis since their JV5# vector equals zero.

BIBLIOGRAPHY

1. Archer, S. H. and L. G. Faerber, " Firm Size and the Cost of Externally Secured Equity Capital," Journal of Finance, March 1966.

2. Armour, H. O. and D. J. Teece, "Organizational Structure and Economic Performance: A Test of the Multidivisional Hypothesis," Bell Journal of Economics, Spring 1978.

3. Asch, P. and J. J. Seneca, "Characteristics of Collusive Firms," Journal of Industrial Economics, March 1975.

4. Bain, J. S., Barriers to New Competition (Harvard University Press, 1956).

5. Balestra, P. and M. Nerlove, "Pooling Cross Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas," Econometrica, July 1966.

6. Berg, S. and P. Friedman, "Joint Ventures, Competition and Technological Complementarities: Evidence from Chemicals," Southern Economic Journal, January 1977.

7. Berg, S. and P. Friedman, "Joint Ventures in American Industry: An Overview," Mergers and Acquisitions, Summer 1978.

8. Berg, S. and P. Friedman, "Causes and Effects of Joint Venture Activity: Knowledge Acquisition vs. Parent Horizontality," Antitrust Bulletin, forthcoming Spring, 1980.

9. Berg, S. and P. Friedman, Government Policy Towards Joint Ventures as a Mechanism Affecting R&D, National Science Foundation Report (RDA 75-19064), 1979.

10. Berg, S. and P. Friedman, "Impacts of Domestic Joint Ventures on Industrial Rates of Return: A Pooled Cross-Section Analysis," working paper, Joint Venture Assessment Project, University of Florida.

11. Boyle, S., "An Estimate of the Number and Size Distribution of Domestic Joint Subsidiaries," Antitrust Law and Economic Review, Spring 1968.

12. Branch, B., "Research and Development Activity and Profitability: A Distributed Lag Analysis," Journal of the Political Economy, October 1974.

13. Comanor, W. S., "Market Structure, Product Differentiation, and Industrial Research," Quarterly Journal of Economics, November 1967.

14. Cowling, K., "On the Theoretical Specification of Industrial Structure - Performance Relationships," European Economics Review, Vol. 8, 1976.

15. Edstrom, A., "Acquisition and Joint Venture Behavior of Swedish Manufacturing Firms," Scandinavian Journal of Economics, Vol. 3, 1976.

16. Energy Information, Vol. 4, No. 49, December 1975.

17. Evans, J. H. and S. H. Archer, "Diversification and the Reduction of Dispersion: An Empirical Analysis," Journal of Finance, December 1968.

18. Financial Accounting Standards Board, "Statement of Financial Accounting Standards No. 2 - Accounting for Research and Development Costs," October 1974.

19. Friedman, P., S. Berg, and J. Duncan, "External vs. Internal Knowledge Acquisition: Joint Venture Activity and R&D Substitution," Journal of Economics and Business, February 1979.

20. Fusfeld, D. R., "Joint Subsidiaries in the Iron and Steel Industry," American Economic Review, May 1958.

21. Gort, M., "An Economic Disturbance Theory of Mergers," Quarterly Journal of Economics, November 1969.

22. Grabowski, H. G., "The Determinants of Industrial Research and Development: A Study of the Chemical, Drug, and Petroleum Industries," Journal of the Political Economy, March/April 1968.

23. Grabowski, H. G. and N. D. Baxter, "Rivalry in Industrial Research and Development," Journal of Industrial Economics, July 1973.

24. Grabowski, H. G. and D. C. Mueller, "Managerial and Stockholder Welfare Models of Firm Expenditures," Review of Economics and Statistics, February 1972.

25. Hall, M. and L. Weiss, "Firm Size and Profitability," Review of Economics and Statistics, August 1967.

26. Hamberg, D., R&D; Essays on the Economics of Research and Development (Random House, 1966).

27. Hlavacek, J. D., B. H. Dovey, and J. J. Biondo, "Tie Small Business Technology to Marketing Power," Harvard Business Review, January 1977.

28. Howe, J. D. and D. G. McFetridge, "The Determinants of R&D Expenditures," Canadian Journal of Economics, February 1976.

29. Jewkes, J., D. Sawers, and R. Stillerman, The Sources of Invention (Norton, 1969).

30. Johnston, J., Econometric Methods (McGraw-Hill, 1972).

31. Kamien, M. I. and N. L. Schwartz, "Market Structure and Innovation: A Survey," Journal of Economic Literature, March 1975.

32. Kmenta, J., Elements of Econometrics (MacMillan, 1971).

33. Kuh, E., Capital Stock Growth: A Micro-Econometric Approach (North Holland, 1963).

34. Kuh, E. and J. Meyer, "Correlation and Regression Estimates When the Data are Ratios," Econometrica, October 1955.

35. Lintner, J., "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets," Review of Economics and Statistics, February 1965.

36. Maddala, G. S., "Self-selectivity Problems in Econometric Models," working paper, University of Florida.

37. Mansfield, E., "Size of Firm, Market Structure, and Innovation," Journal of the Political Economy, December 1963.

38. Mansfield, E., Industrial Research and Technological Innovation - An Econometric Analysis (Norton, 1968).

39. Mansfield, E. and J. Rapoport, "The Cost of Industrial Product Innovations," Management Science, August 1975.

40. Markowitz, H. M., Portfolio Selection (John Wiley and Sons, 1959).

41. Mead, W. J., "The Competitive Significance of Joint Ventures," Antitrust Bulletin, Fall 1967.

42. Meehan, J. W., "Joint Venture Entry in Perspective," Antitrust Bulletin, Winter 1970.

43. Mossin, J., "Equilibrium in a Capital Assets Market," Econometrica, October 1966.

44. Mueller, D. C., "Patents, Research and Development, and the Measurement of Inventive Activity," Journal of Industrial Economics, November 1966.

45. Mueller, D. C., "The Firm Decision Process: An Econometric Investigation," Quarterly Journal of Economics, February 1967.

46. Pfeffer, J. and P. Nowack, "Patterns of Joint Venture Activity: Implications for Antitrust Policy," Antitrust Bulletin, Summer 1976.

47. Phillips, A., "Patents, Potential Competition, and Technical Progress," American Economic Review, Part II Supplement, May 1966.

48. Pindyck, R. S. and D. L. Rubinfeld, Econometric Models and Economic Forecasts (McGraw-Hill, 1976).

49. Rhodes, S. A., "The Effect of Diversification on Industry Profit Performance in 214 Manufacturing Industries: 1963," Review of Economics and Statistics, January 1973.

50. Ross, S. A., "Return, Risk, and Arbitrage," in Risk and Return in Finance, Vol. 1, ed. Friend, I. and J. Bicksler (Ballinger Publishing Co., 1977).

51. Scherer, F. M., "Size of Firm, Oligopoly, and Research: A Comment," Canadian Journal of Economics and Political Science, May 1965.

52. Scherer, F. M., "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions," American Economic Review, December 1965.

53. Scherer, F. M., "Market Structure and the Employment of Scientists and Engineers," American Economic Review, June 1967.

54. Scherer, F. M., "Research and Development Resources Allocation Under Rivalry," Quarterly Journal of Economics, August 1967.

55. Scherer, F. M., Industrial Market Structure and Economic Performance (Rand McNally, 1970).

56. Sharpe, W. F., "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk," Journal of Finance, September 1964.

57. Standard and Poor's Corporation, Compustat Industrial Manual (Investment Management Sciences, Inc., 1975).

58. Tobin, J., "Liquidity Preference as Behavior Towards Risk," Review of Economic Studies, February 1958.

59. Turner, D. F., "Conglomerate Mergers and Section 7 of the Clayton Act," Harvard Law Review, Vol. 78, 1965.

60. Wippern, R. F., Testimony Before the Subcommittee on Monopolies and Commercial Law of the Committee on the Judiciary, House of Representatives, Ninety-fourth Congress, No. 48, Part 1.

61. Worley, J. S., "Industrial Research and New Competition," Journal of the Political Economy, April 1961.

BIOGRAPHICAL SKETCH

I was born on December 31, 1946, in Farmville, Virginia. The majority of my childhood was spent in Pensacola, Florida, where I attended high school at Pensacola Catholic High during 1960-1964. I next attended the University of Florida in 1964-1965, Pensacola Junior College in 1965-1966, and the University of Florida for the beginning of the 1967 school year. The years 1968-1971 I spent in the U.S. Army. In the years 1971-1972 I returned to the University of Florida, where I received my BSBA with high honors in December, 1972, majoring in management. I started graduate school in January, 1973 with the intention of working for my PhD.

I attended graduate school, focusing primarily on management and finance, until June, 1977. During this period I first worked as a graduate assistant under Drs. Arditti, Brigham, Cornelius, and McCullough during 1973-1975; I then worked on a National Science Foundation (NSF) grant awarded to Drs. Berg and Friedman to study Joint Ventures. The dissertation is substantially a result of my work on the NSF grant. After completion of graduate coursework in June, 1977, I accepted a teaching position at the University of Texas of the Permian Basin in September, 1977. I held that position until August, 1979, at which time I accepted a position as Assistant Professor at the University of Manitoba in September, 1979, where I currently teach finance courses in the Department of Accounting and Finance.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

H. Russell Fogler

H. Russell Fogler, Chairman
Professor of Management

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Sanford V. Berg

Sandford V. Berg
Associate Professor of Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Richard A Elnicki

Richard Elnicki
Associate Professor of Management

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

W. Andrew McCollough
Associate Professor of Finance

This dissertation was submitted to the Graduate Faculty of the Department of Management in the College of Business Administration and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Dean, Graduate School